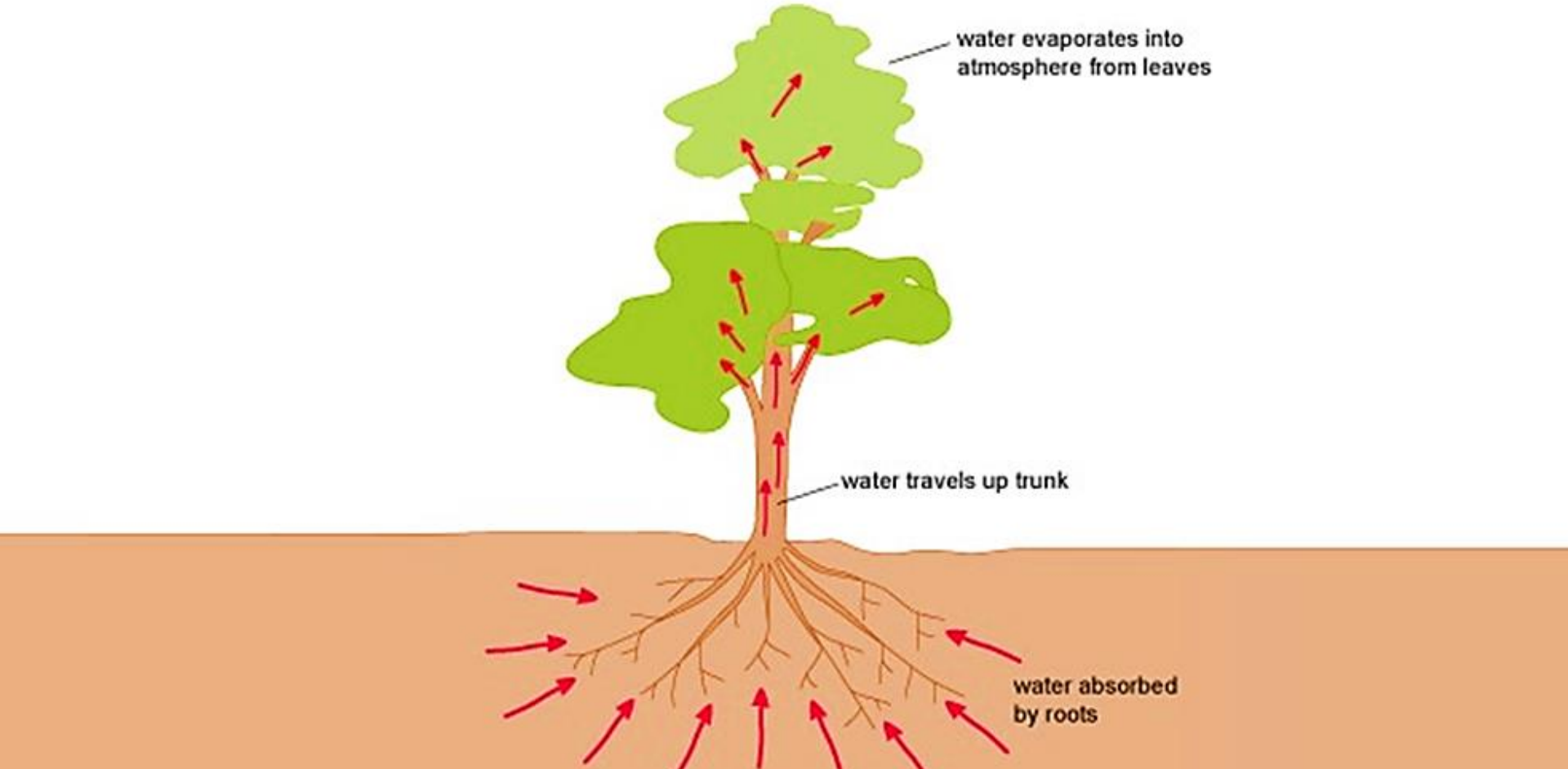
Cambridge Assessment International Education

AS Level
Chapter 7

# Transport In Plants



# Chapter Outline

**Part 1: Plant Anatomy**

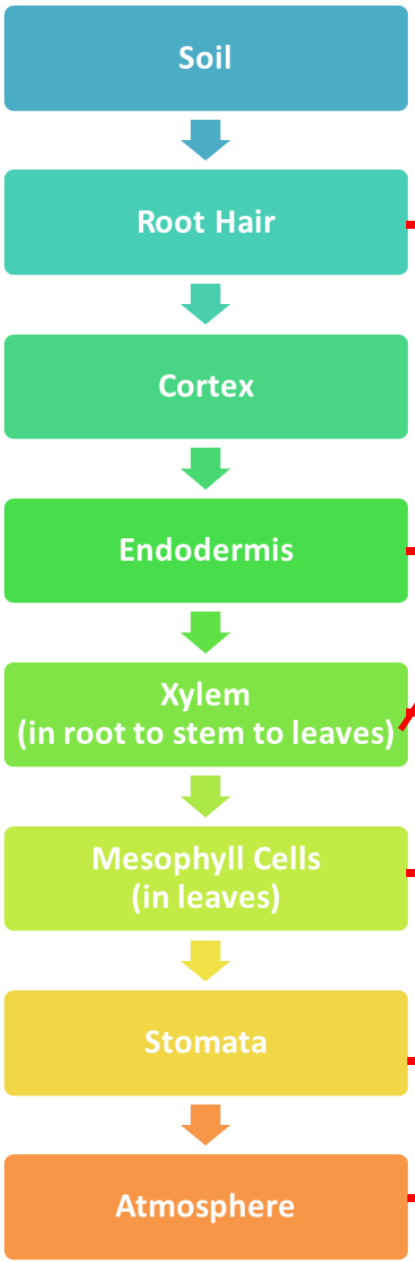
- Structure of Xylem Vessel Elements, Phloem Sieve Tubes and Companion Cells

**Part 2: Transport of Water and Ions**

**Part 3: Translocation of Sucrose**

# Transport of Water and Ions

*always explain in terms of **water potential**




1) Symplastic pathway
2) Apoplastic pathway
   - Casparian strip

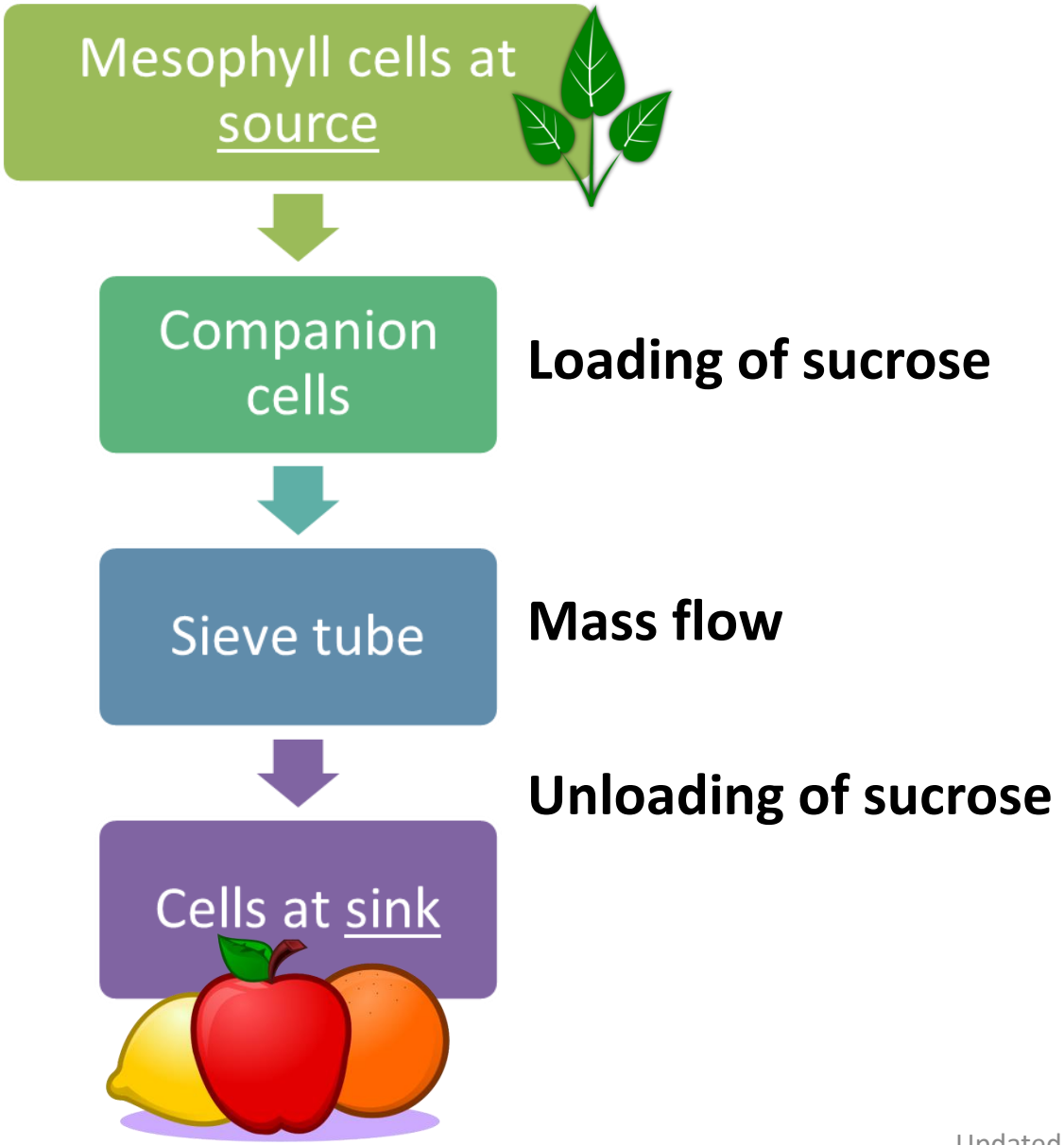
Mechanisms for movement of water in xylem vessels
1) Transpirational pull
2) Cohesion and adhesion of water
3) Root pressure

Symplastic/apoplastic pathway to mesophyll cell surface

Transpiration
- Factors that affect transpiration rate
- Measuring rate of transpiration using a potometer
- Xerophytes: adaptations to reduce transpiration

Updated on 12/8/21 by Beh SJ @behlogy

# Translocation of Sucrose



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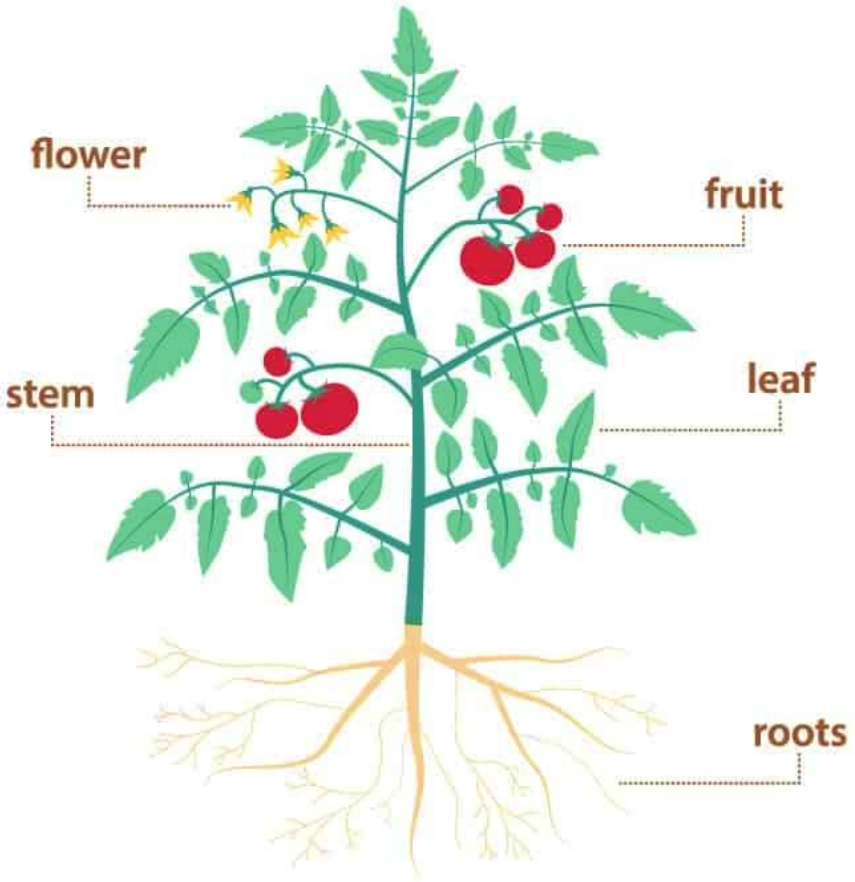
# Transport In Plants

## Plant Anatomy

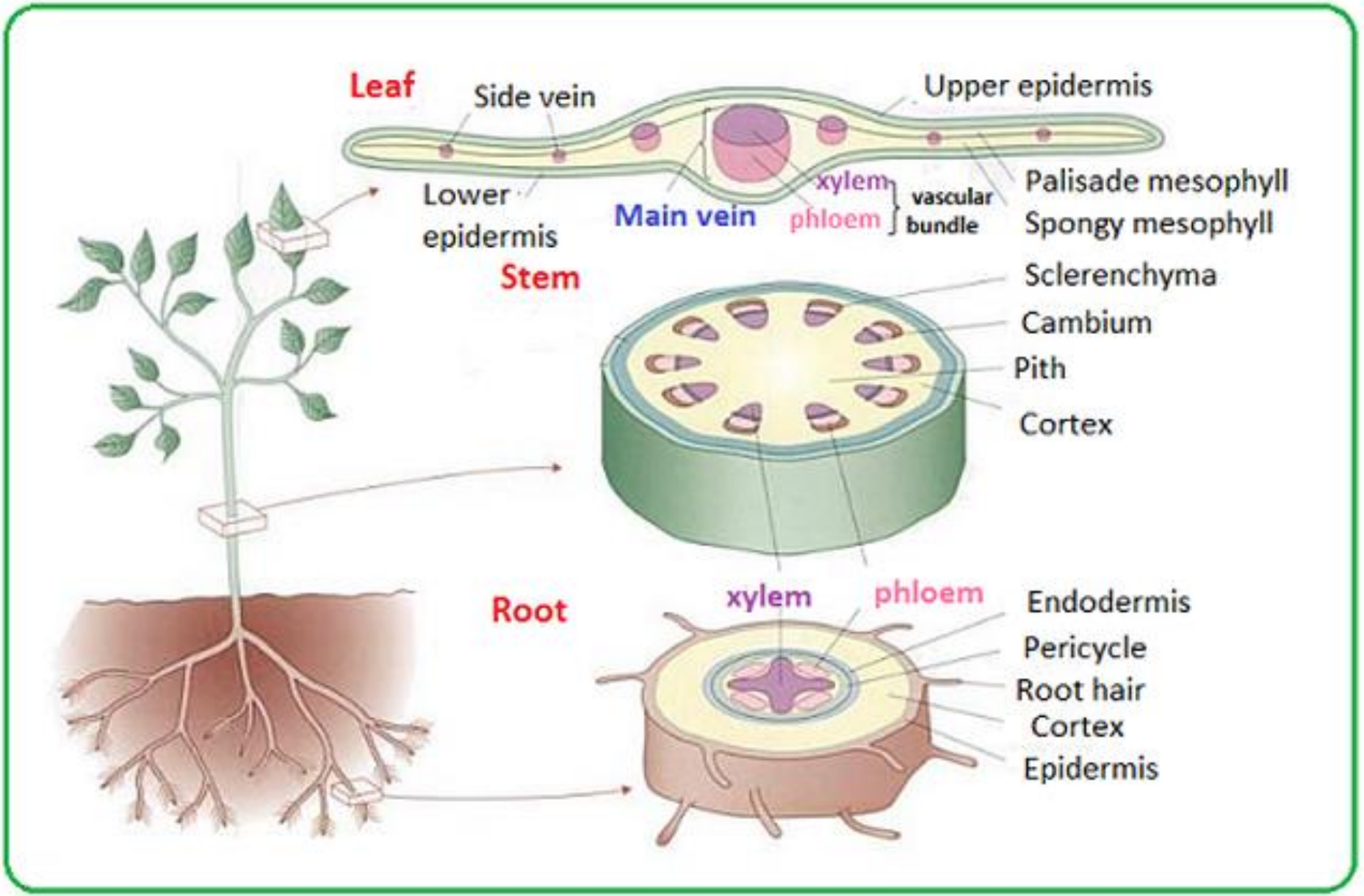


# Q: Why do all multicellular plants and animals need transport systems anyway?

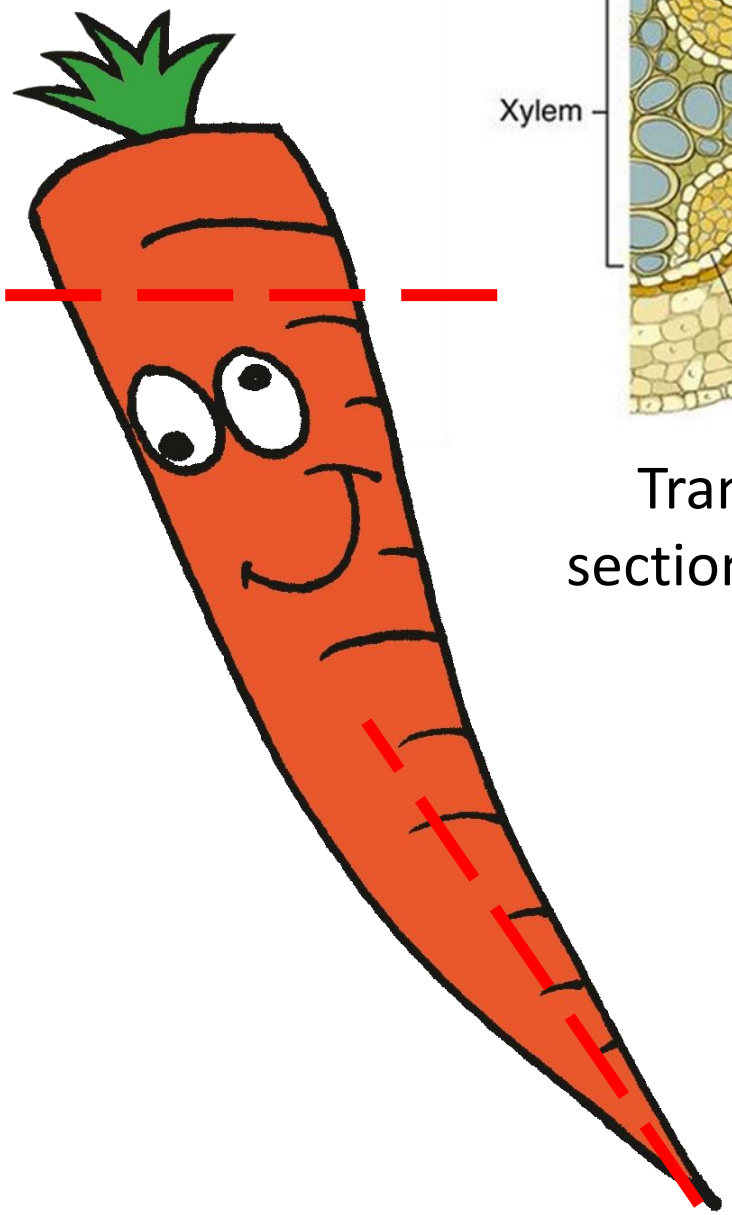
A:

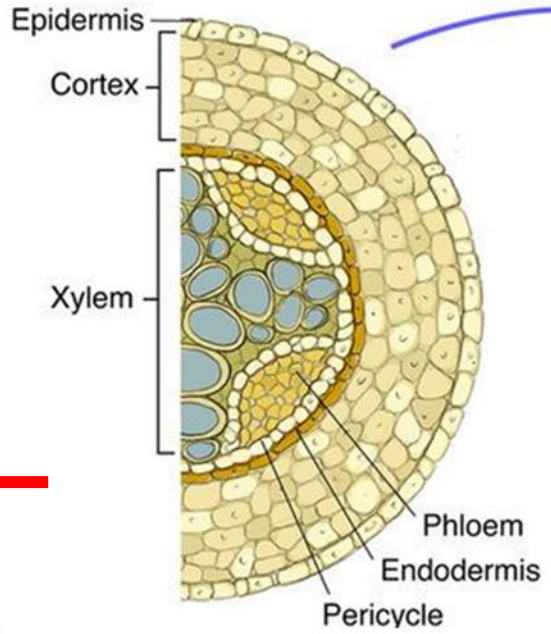
- Small SA:V ratio compared to unicellular organisms
- Longer distance for gas/ nutrients/ hormones to reach tissues
- Higher demand for nutrients/gas
- Diffusion alone too slow to satisfy needs
- Efficient supply of gas/ nutrients/ hormones needed!

→ Transport systems reduce diffusion distance, can transports large amounts of required materials and is efficient!

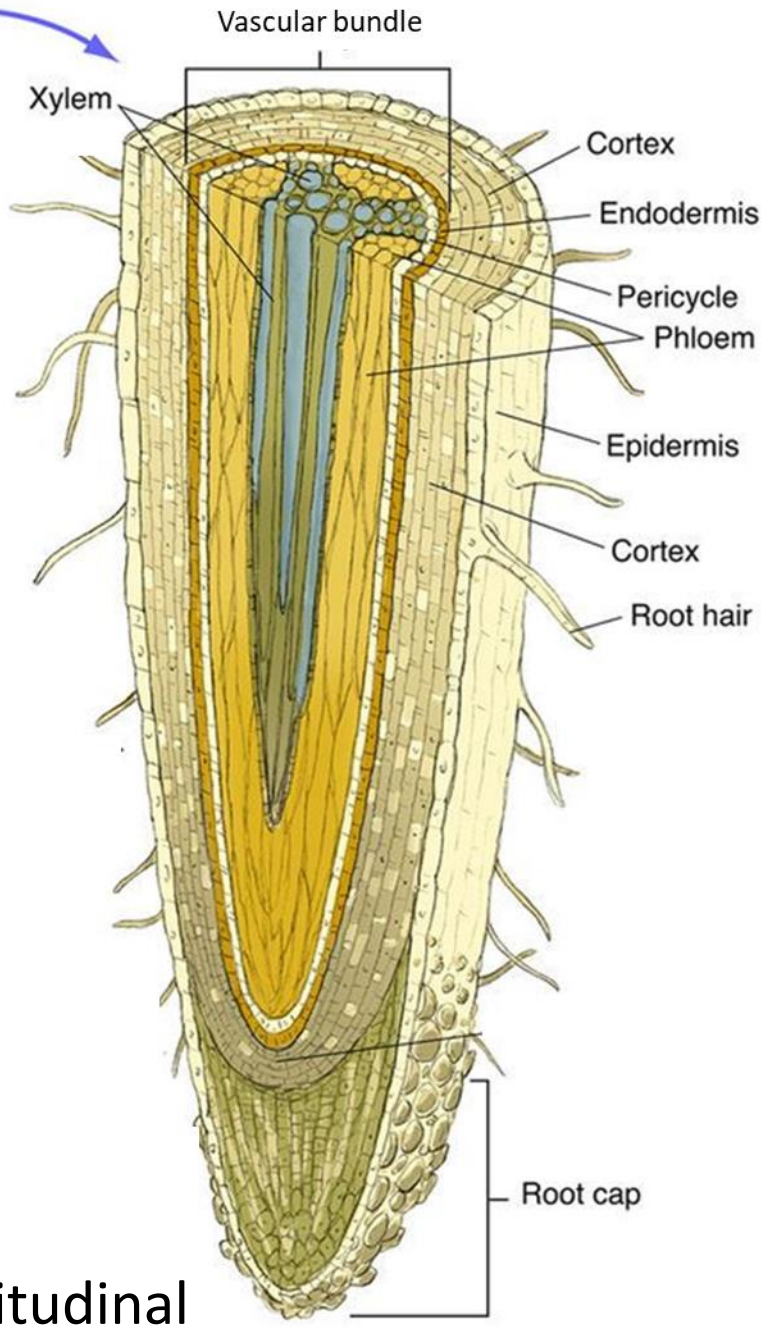



Note: <u>We study dicotyledonous plant anatomy only.</u>
Monocotyledonous plants have similar transport system but their xylem and phloem are placed differently.



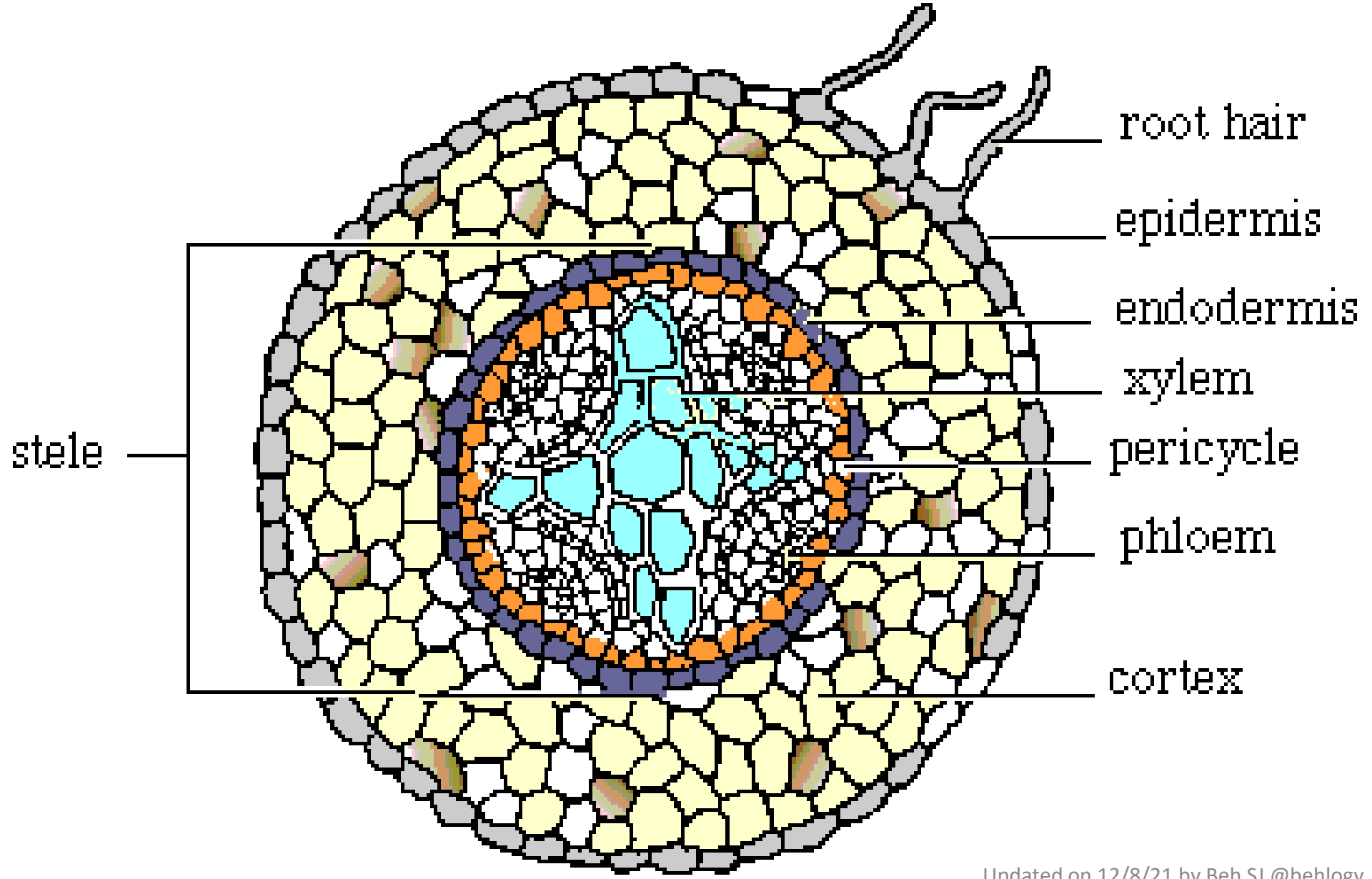



Transverse section of ROOT

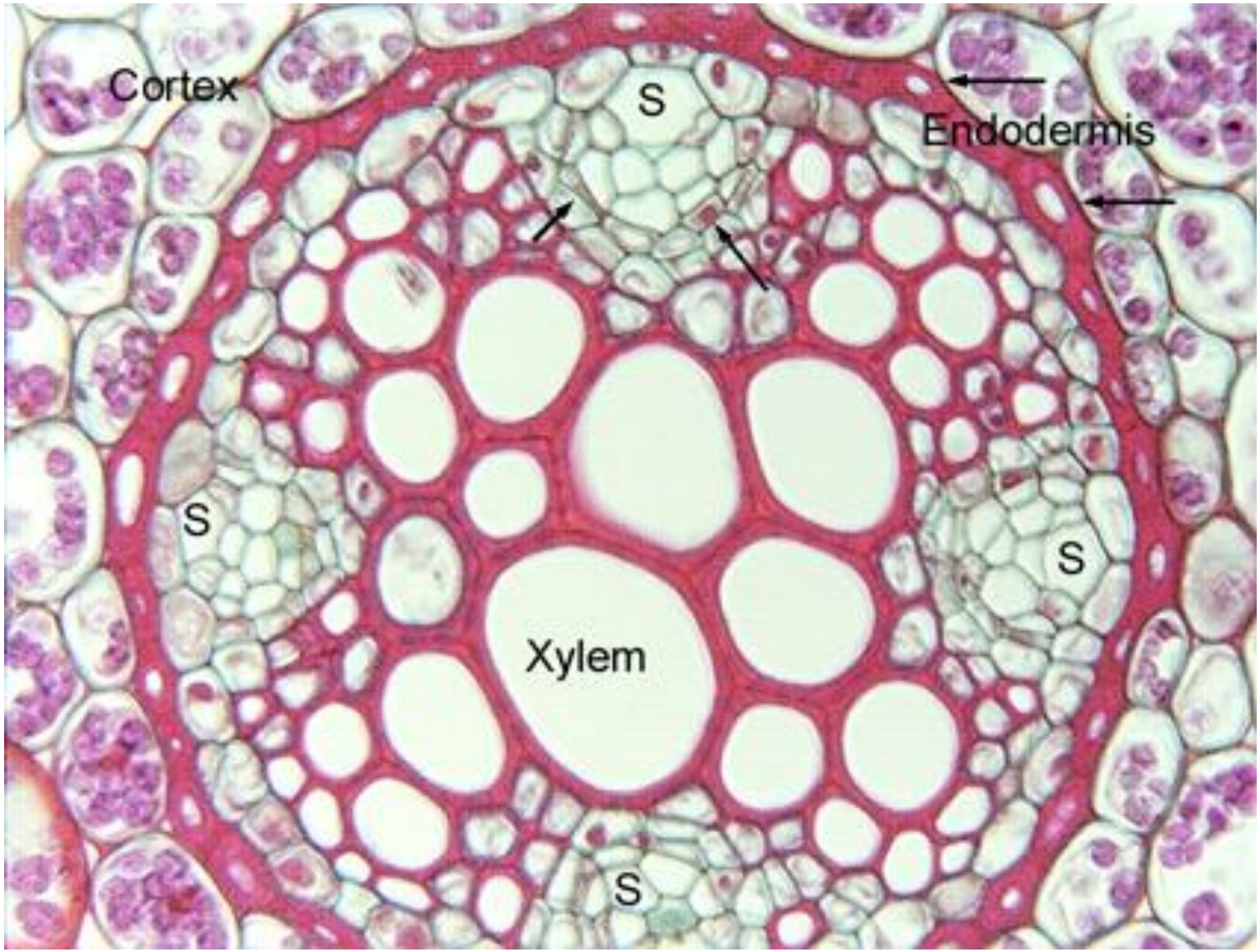



Longitudinal section of ROOT

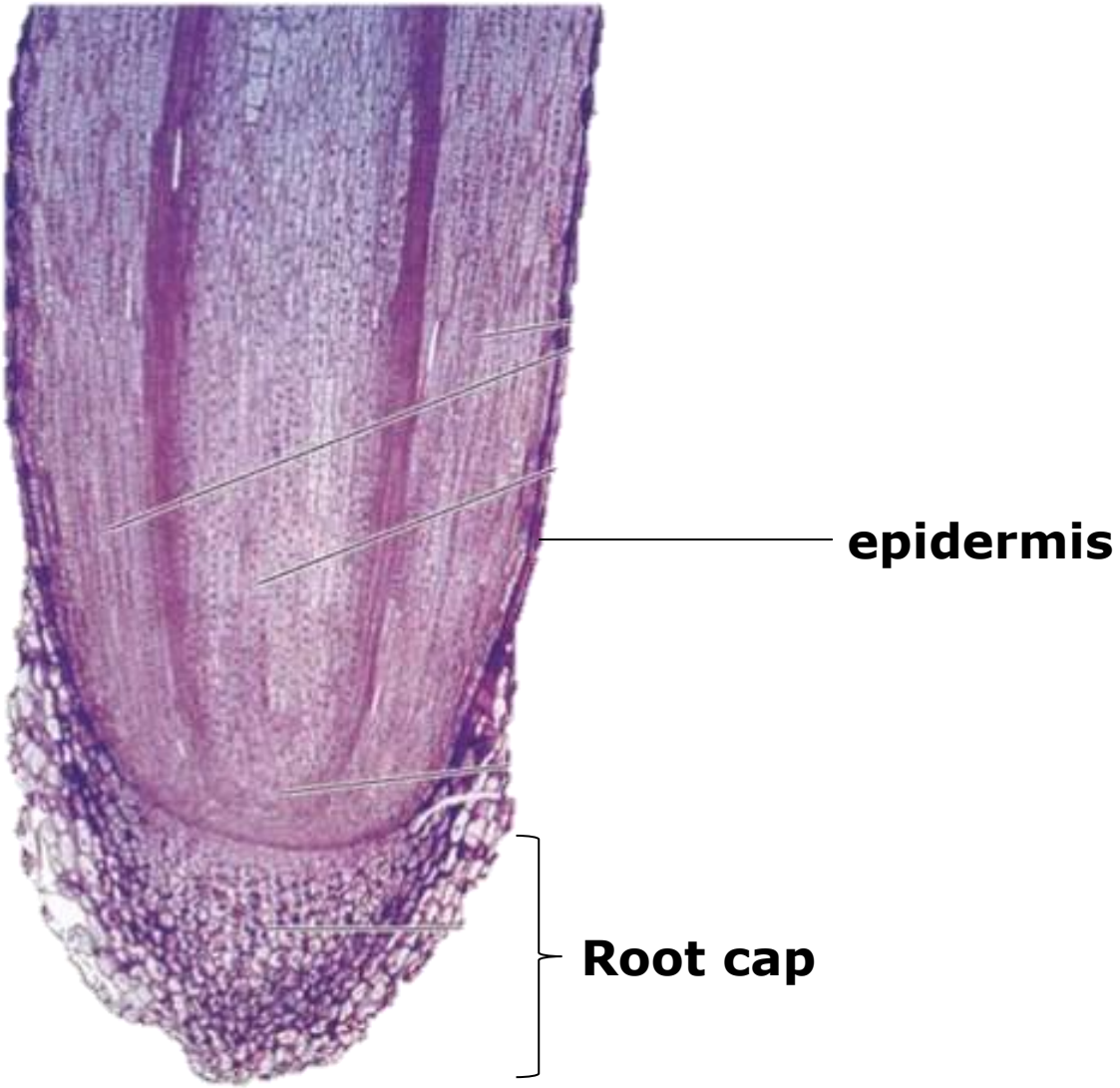
# Transverse section of ROOT



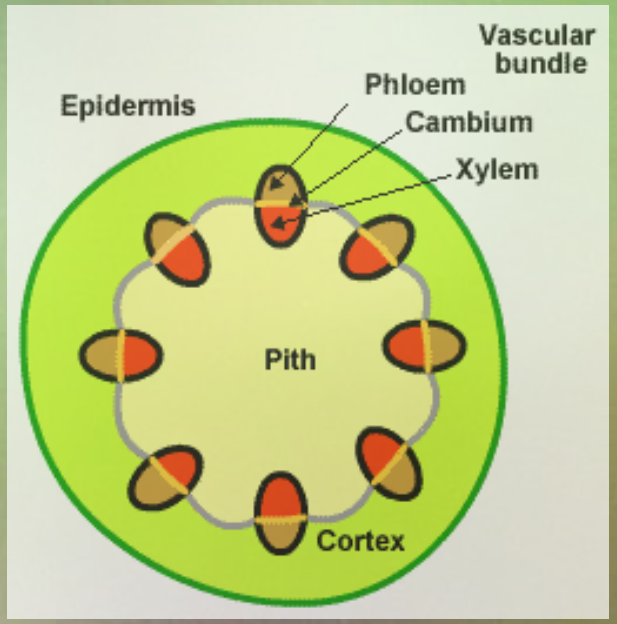
# Transverse section of ROOT

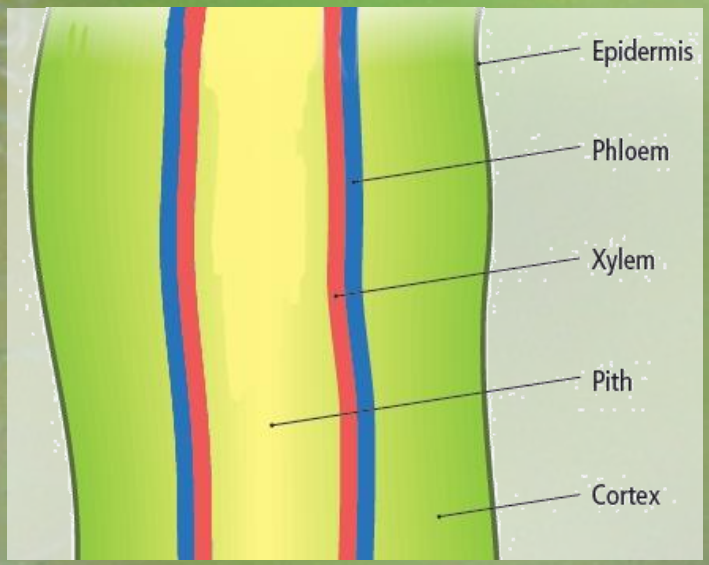


# Longitudinal section of ROOT



# Transverse section of STEM

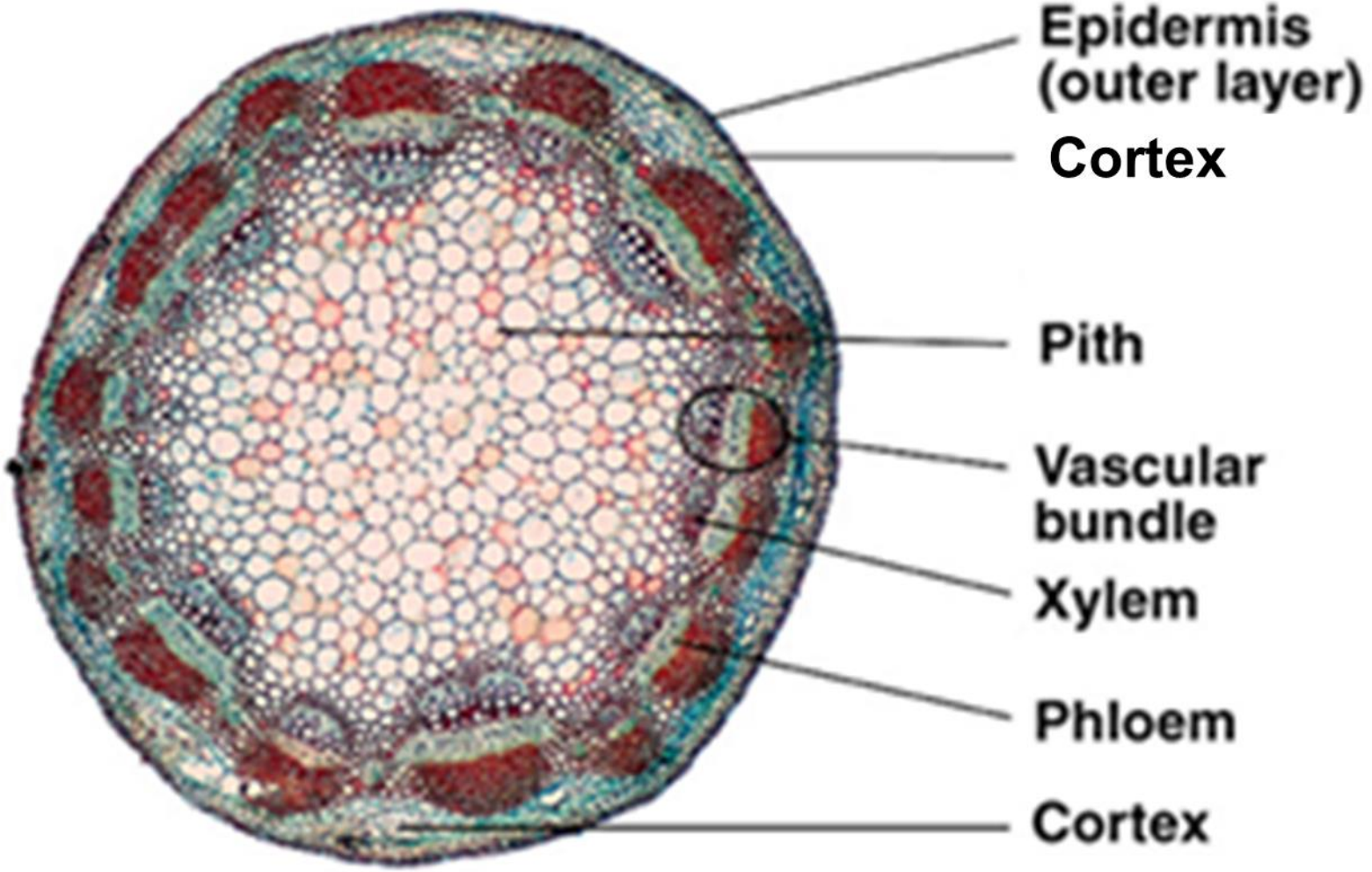


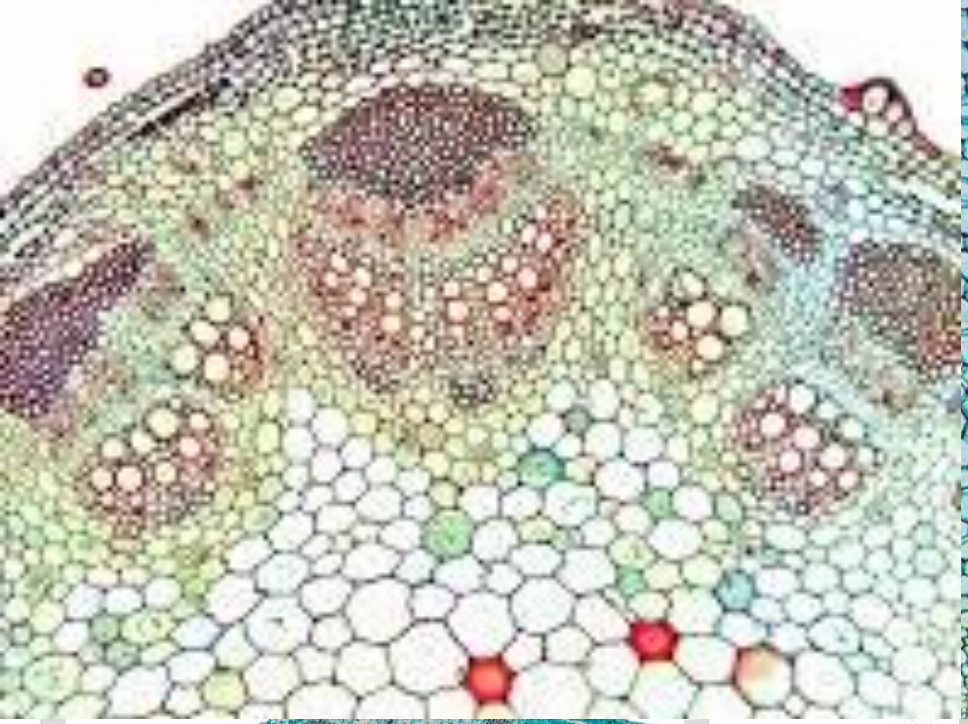



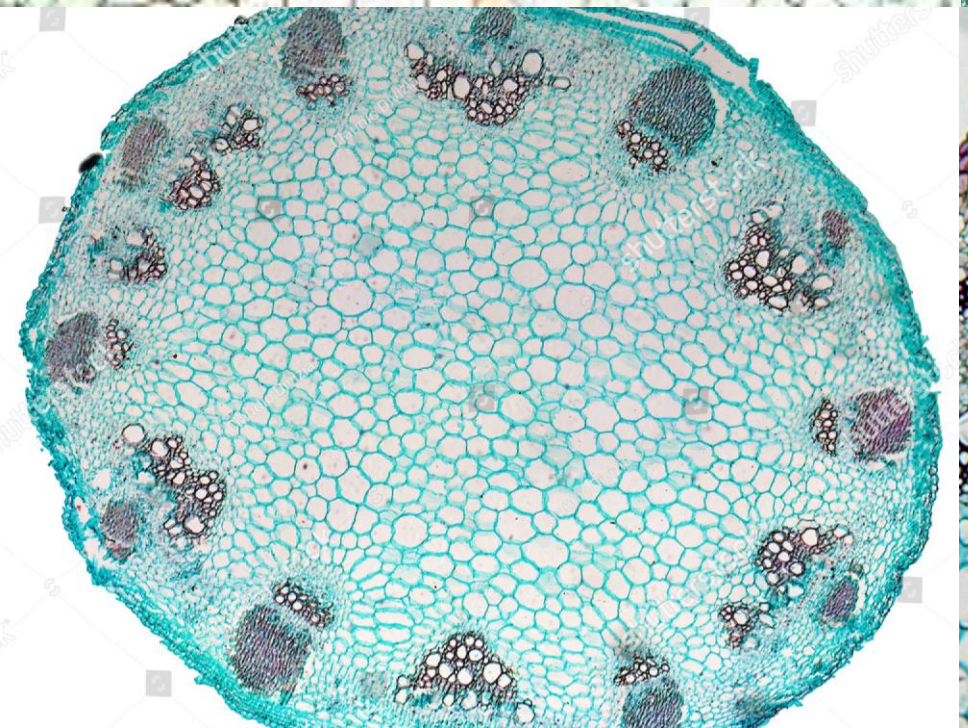

# Longitudinal section of STEM

Updated on 12/8/21 by Beh SJ @behlogy

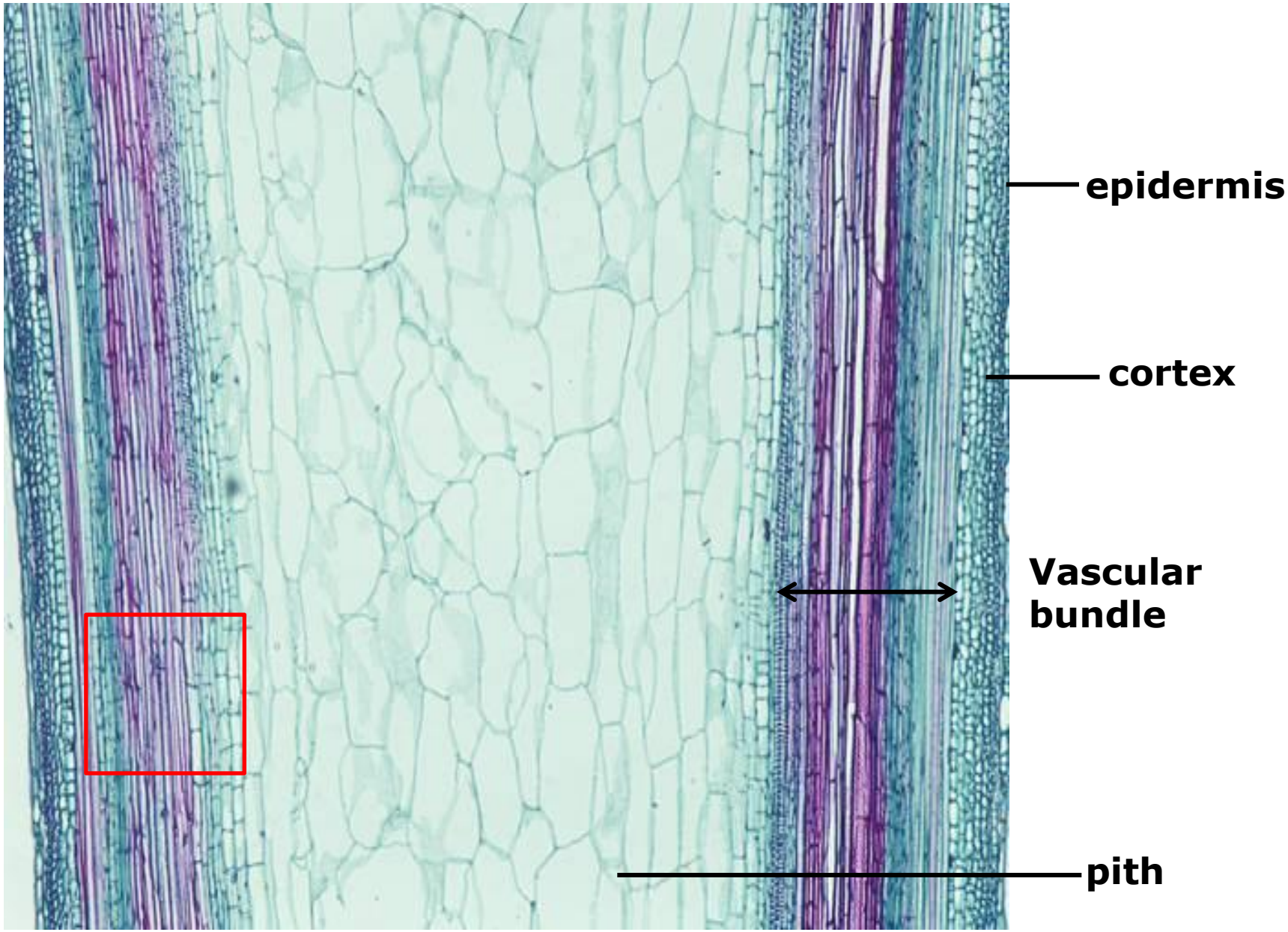
# Transverse section of STEM



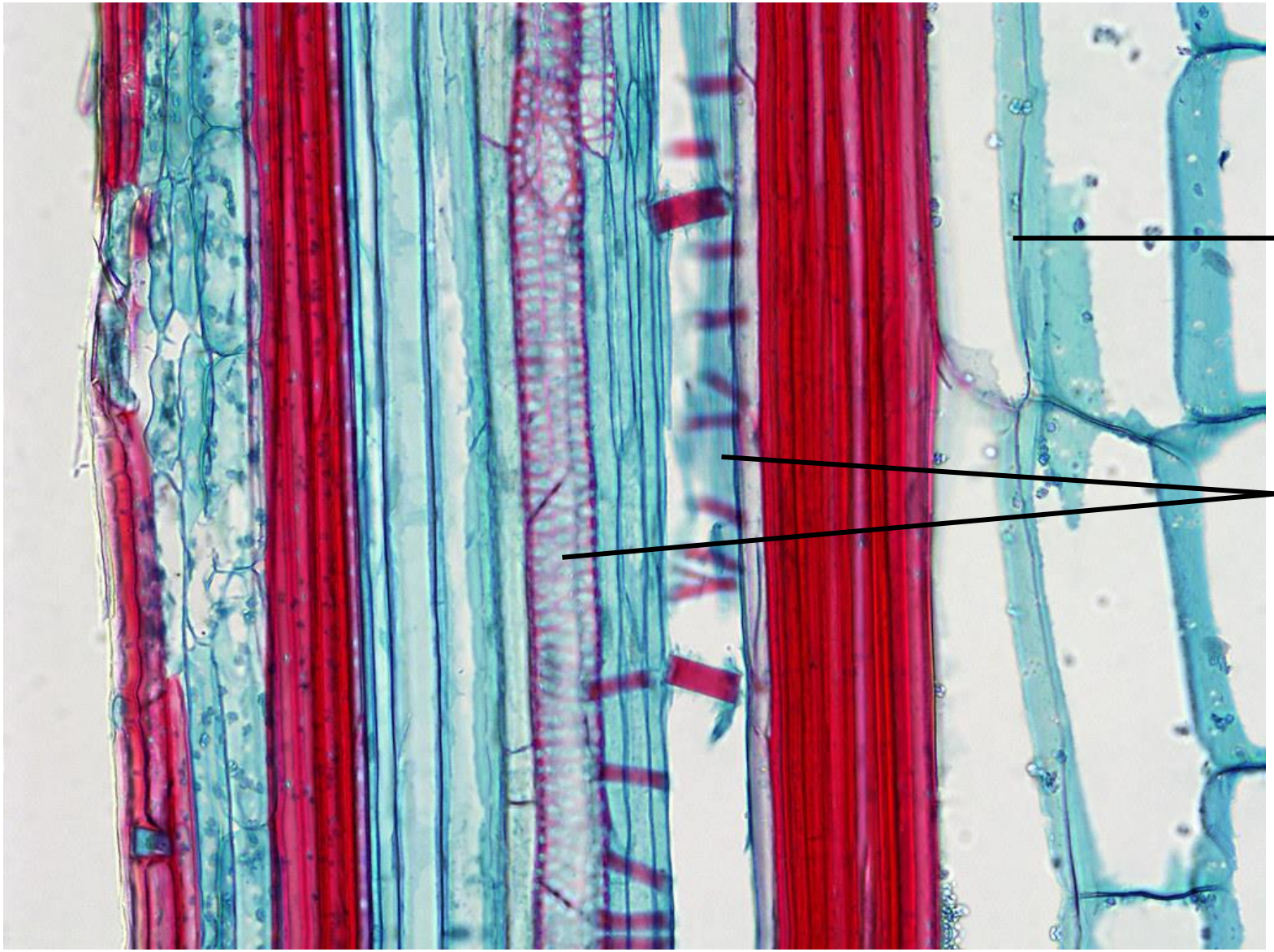


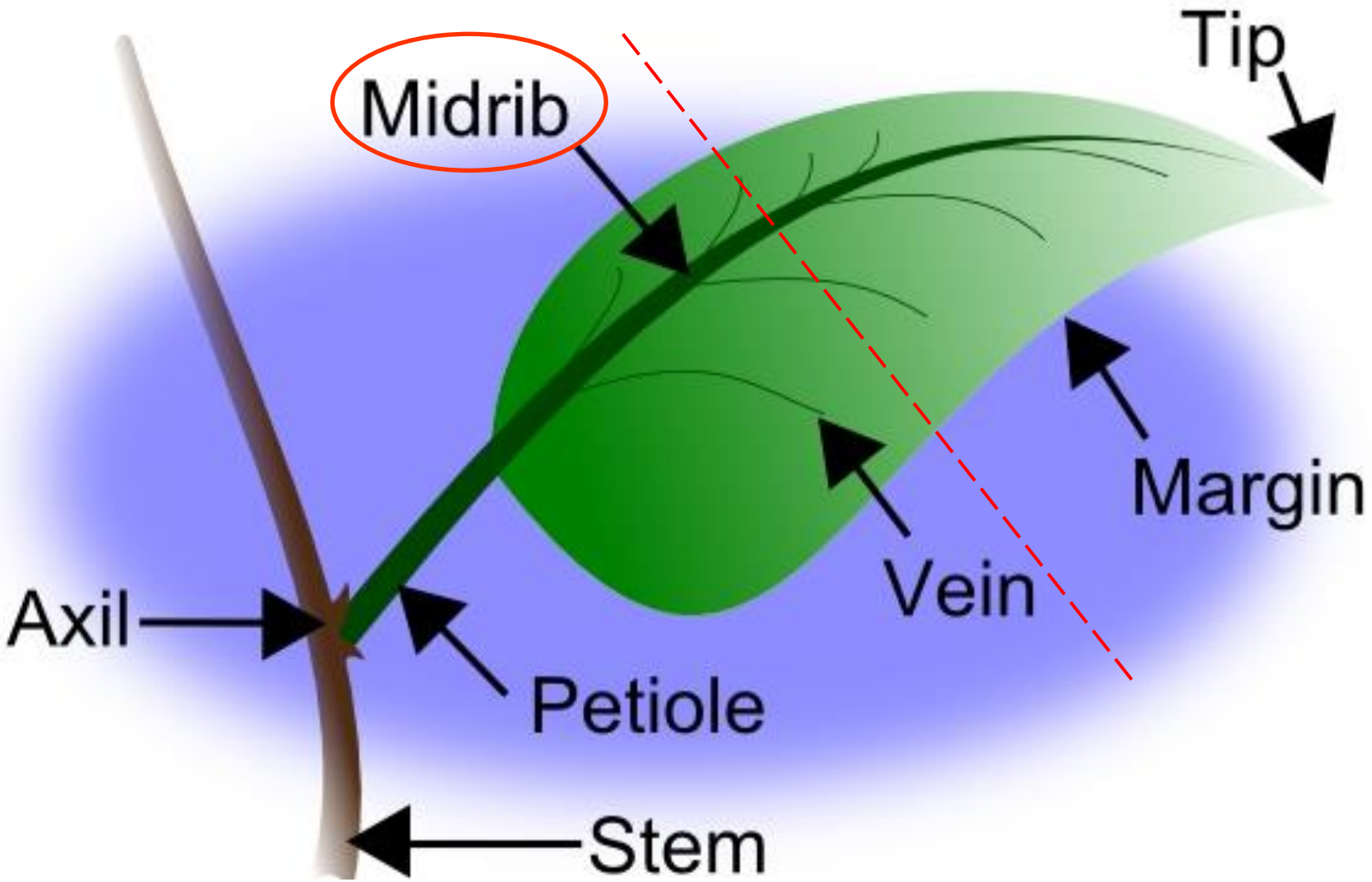


# Longitudinal section of STEM

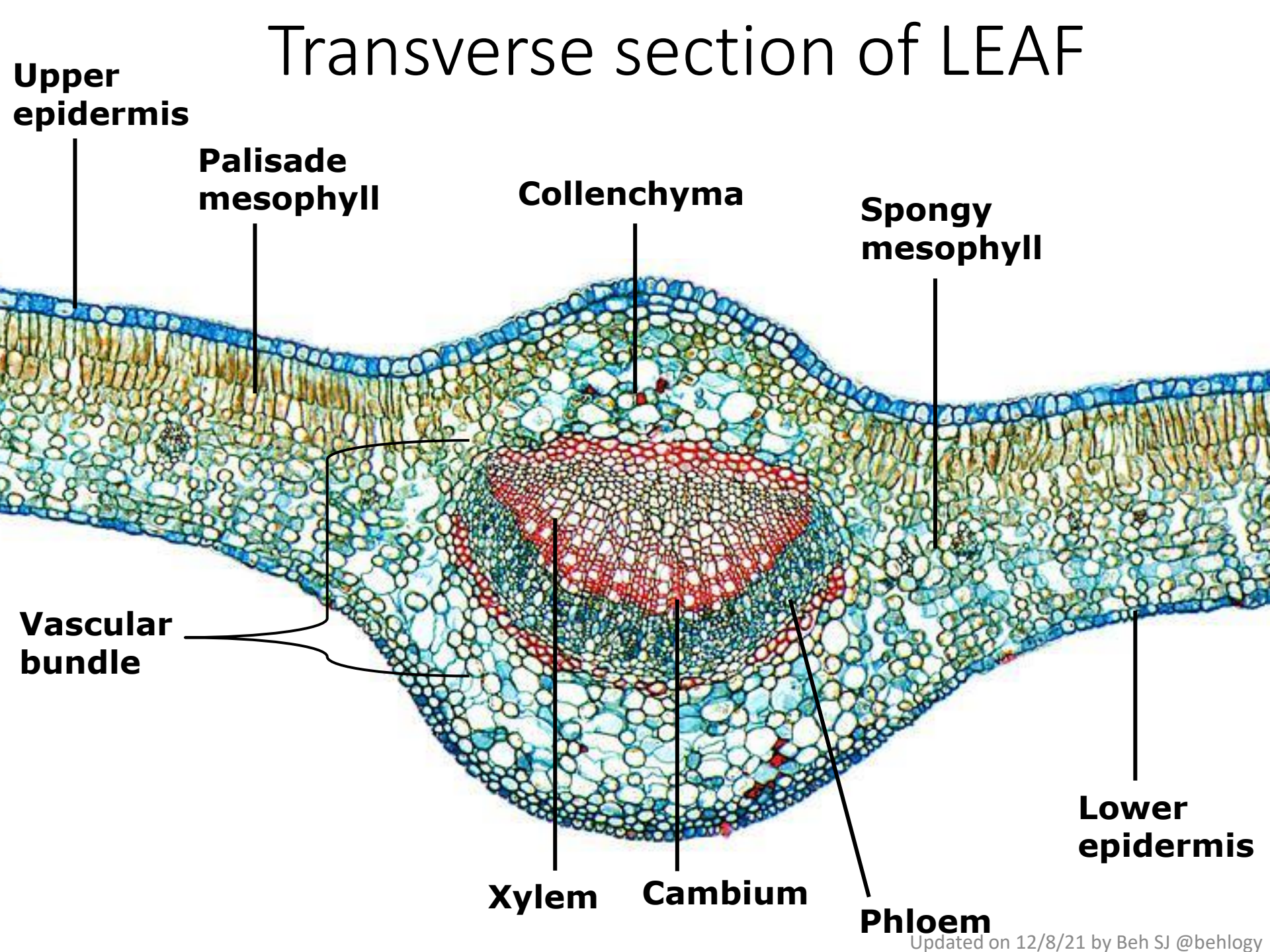


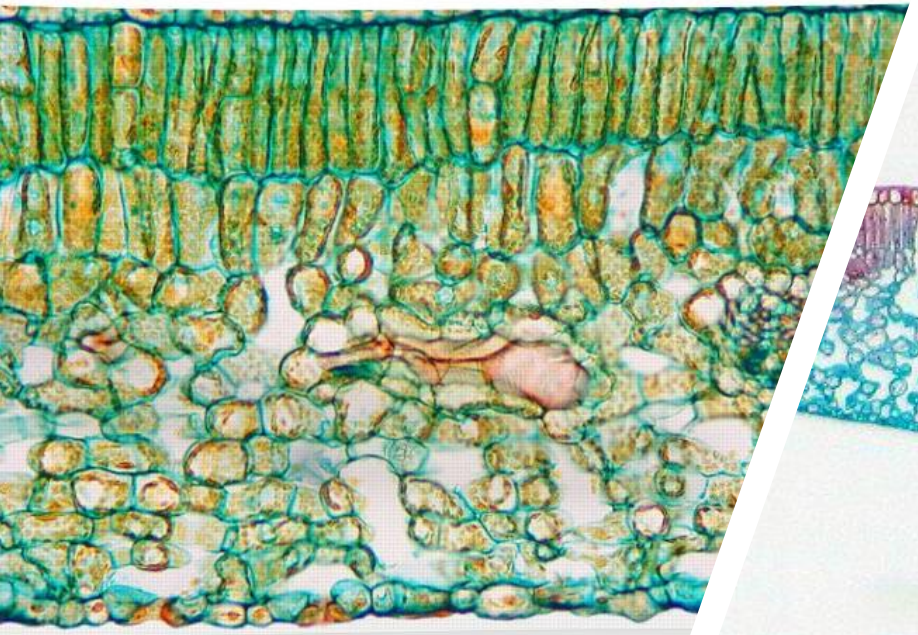
# Longitudinal section of STEM

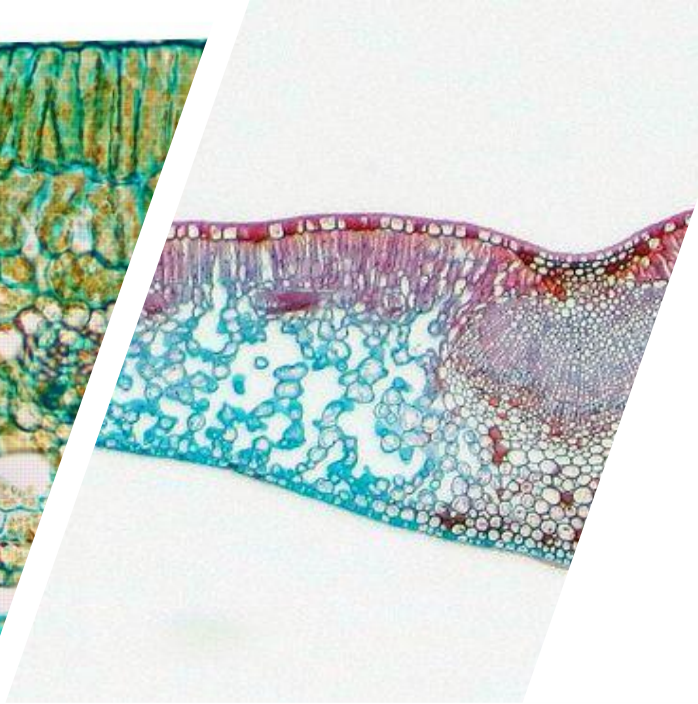


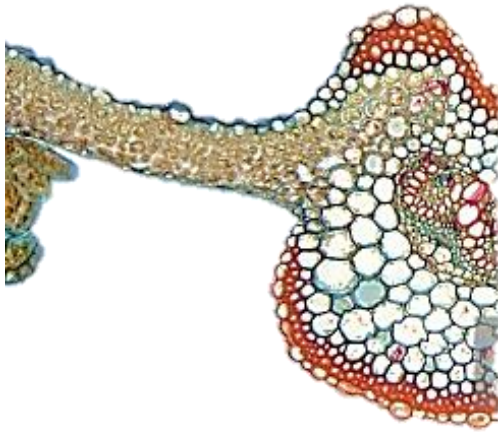

Midrib
Tip
Margin
Vein
Axil
Petiole
Stem

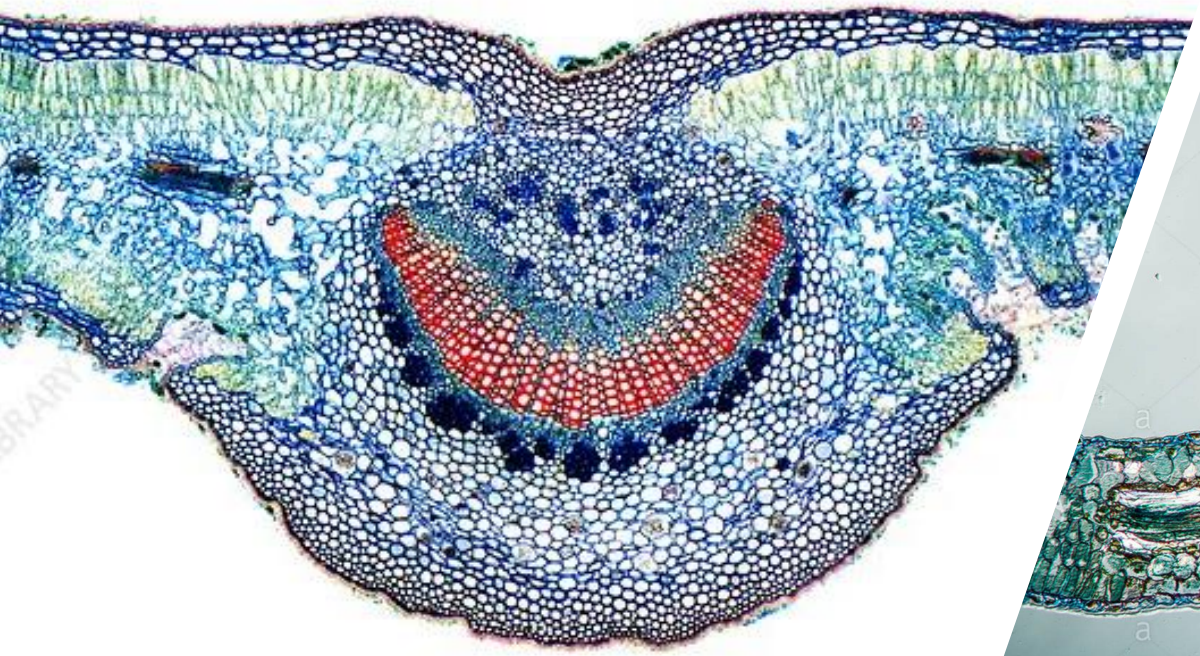
# Transverse section of LEAF











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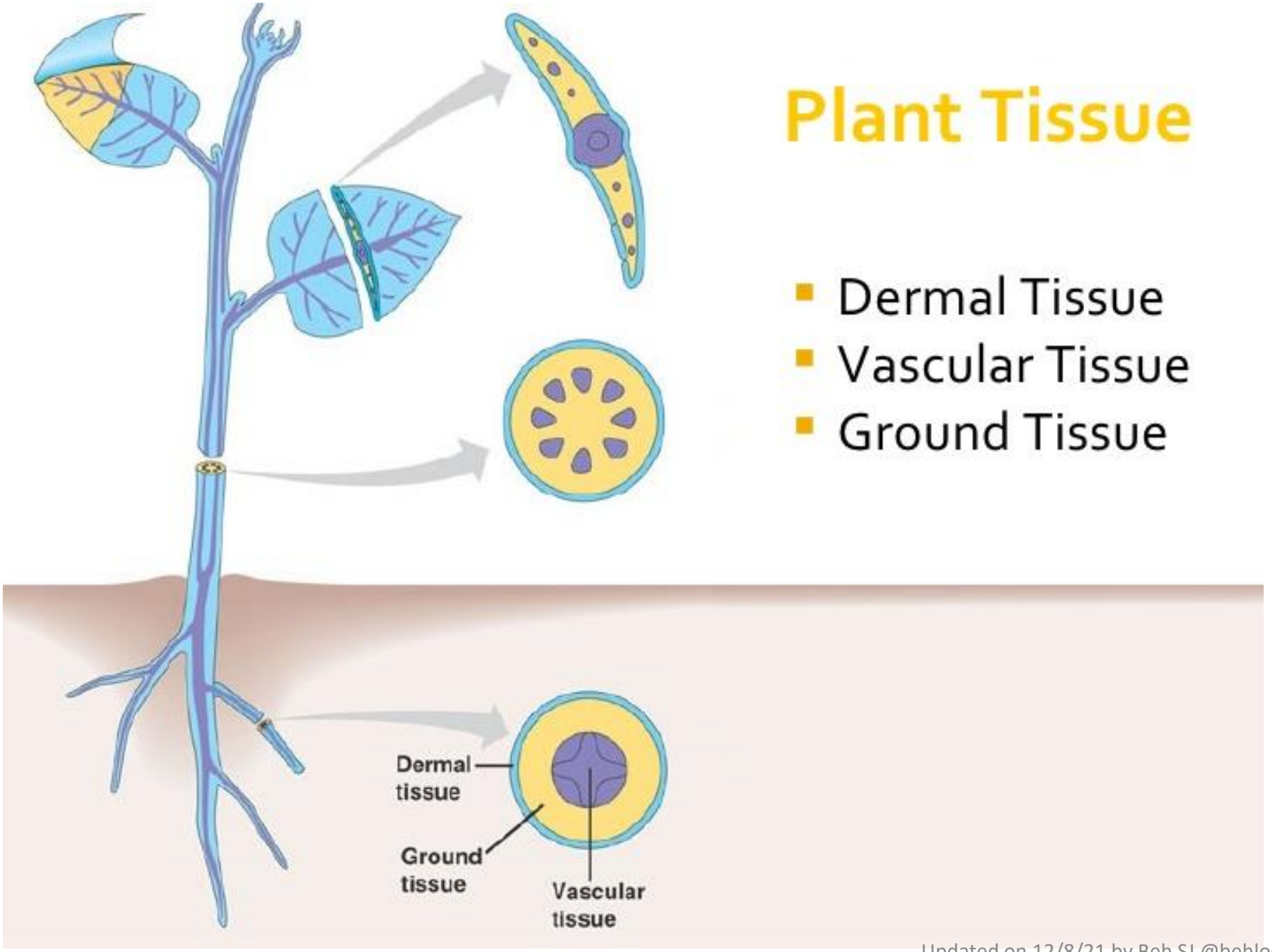
# Plant Tissue

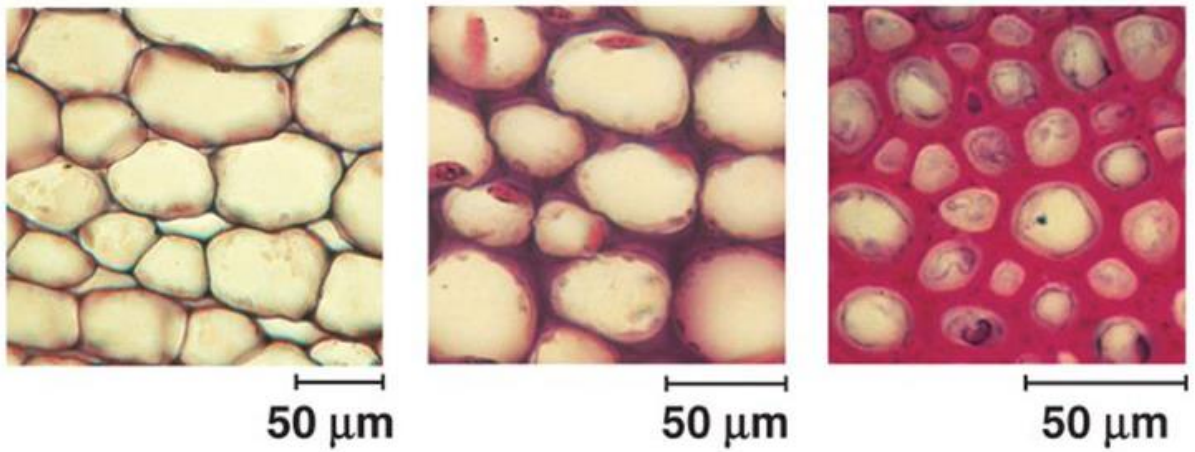
- Dermal Tissue
- Vascular Tissue
- Ground Tissue



# Ground Tissue

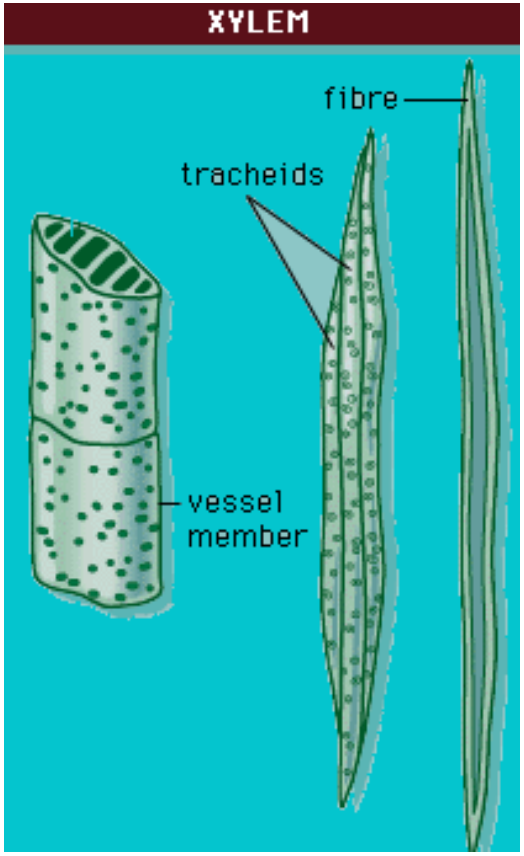
## Parenchyma vs Collenchyma vs Sclerenchyma cells

Ground tissue includes all tissues except vascular bundle and epidermis.




| | Parenchyma | Collenchyma | Sclerenchyma |
|---|---|---|---|
| Thickness of cell wall | Thin | Thicker | Thickest (has lignin) |
| Example | Cortical cells, pith cells, mesophyll cells | Outer cortical cells | Cortical cells of harder stems / tree branches |
| Functions | Photosynthesis, storage of nutrients, cell division | Structural support | Non-living, only for support |

# Vascular Tissue
## Xylem and Phloem




- Tissues are made of many cells

Different types of cells in **xylem** tissue:

a) **Vessel elements / Xylem vessels**
b) Tracheids
c) Fibres
d) Parenchyma cells

Different types of cells in **phloem** tissue:

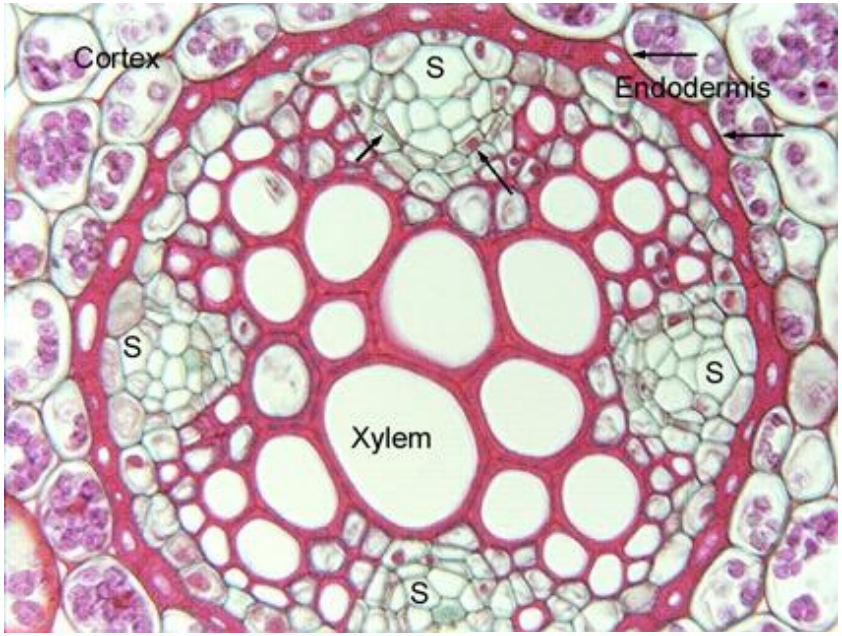
a) **Sieve tube elements**
→ joined end to end to form **sieve tubes**
b) **Companion cells**

# Xylem

Functions:

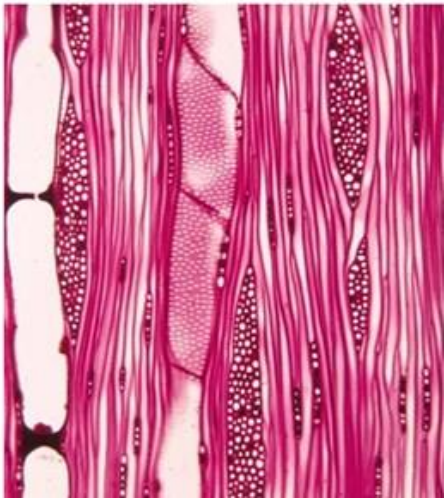
a) **Structural support**

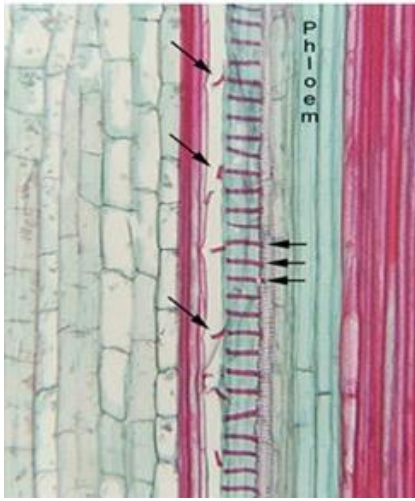
b) **Transport of water** from root to leaves to atmosphere




Appearance under microscope:

- Cell wall have **lignin** bands, in addition to cellulose
- Lignin = strong, hard, waterproof substance






→ Bands can have diff patterns (e.g. rings, spiral, reticulated)

→ Thicker cell wall observed

→ Safranine dye stains xylem in red

# Xylem Vessels

- Also known as vessel elements
- Made of **elongated cells joined end to end**

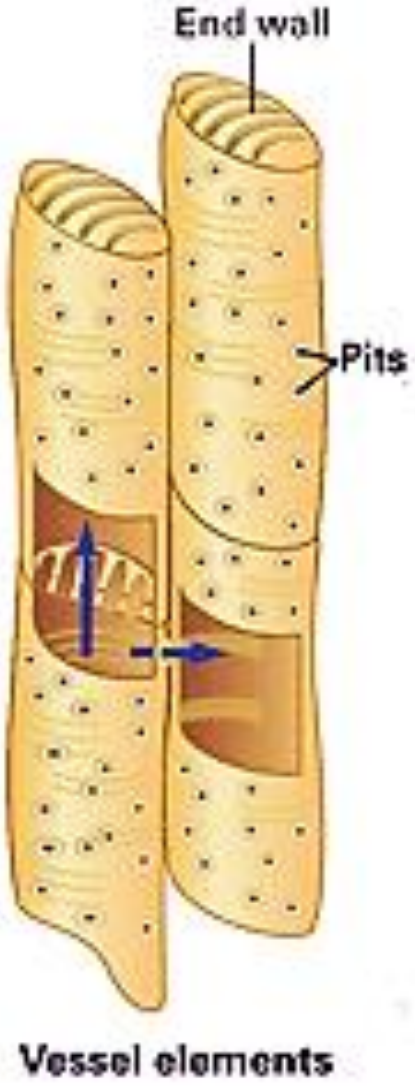
**Structure and how its related to its *function*:**

- Xylem vessels are **non-living**

→ **No cytoplasm, no organelles, hollow lumen**

→ So ***more space for greater volume*** of water to flow

→ ***Less resistance*** to flow of water

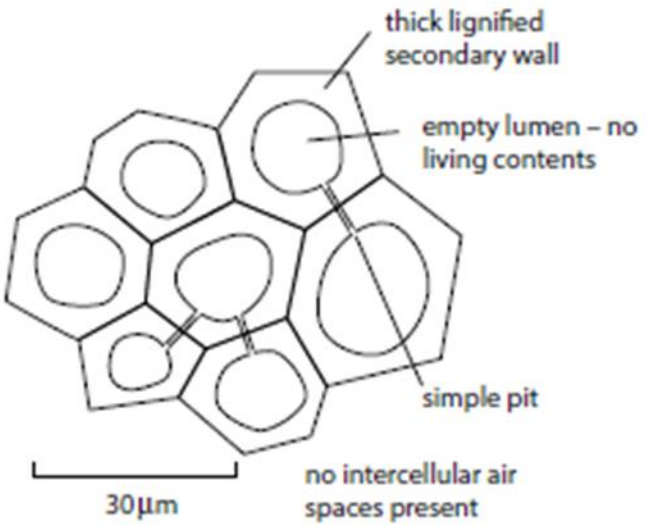


# Xylem Vessels

- **Thick** cell walls made of **cellulose**

→ ***Structural support***

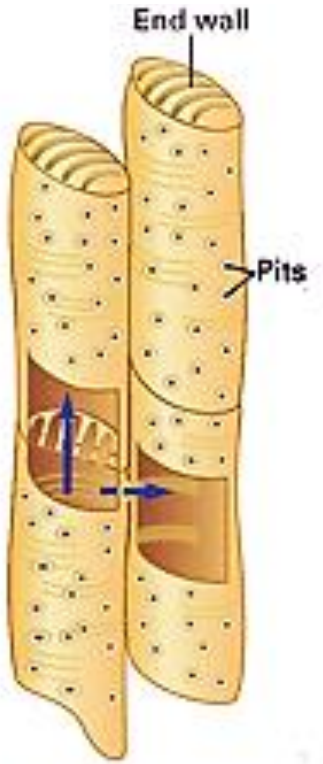
→ Allows ***adhesion of water***




- Cell walls contain **lignin**

→ ***Prevents inward collapse*** as xylem vessel is under tension

→ Also ***waterproof*** to prevent loss of water




- **No end walls**

→ ***Less resistance*** to flow of water

→ Forms a ***continuous tube joined end to end***

# Xylem Vessels

**Large lumen**

→ ***Large volume*** of water can be transported

- **Pits**

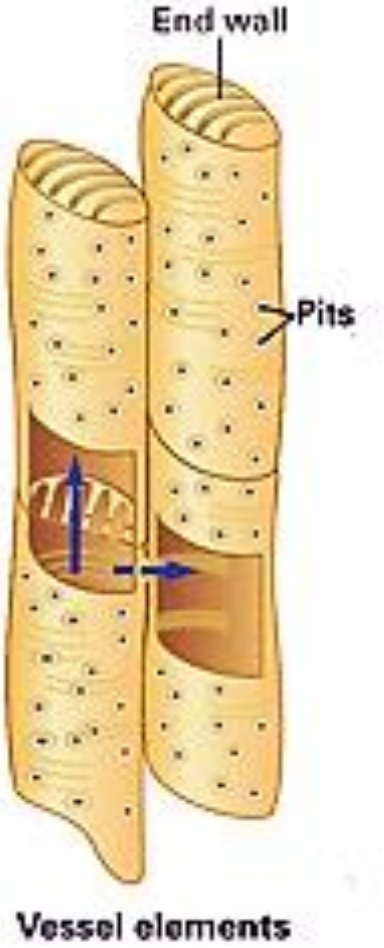
→ Formed from plasmodesmata

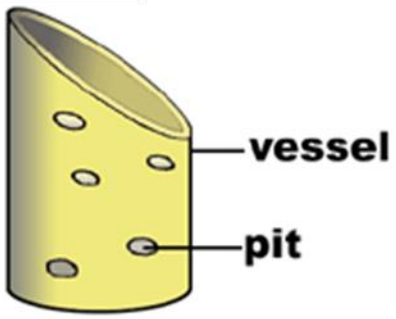
→ No lignin

→ ***Allow lateral movement of water***

→ To connect to all parts of plant

→ If there is a air bubble blocking vessel, pits allow water to move out into another xylem vessel and bypass airlock



# Phloem

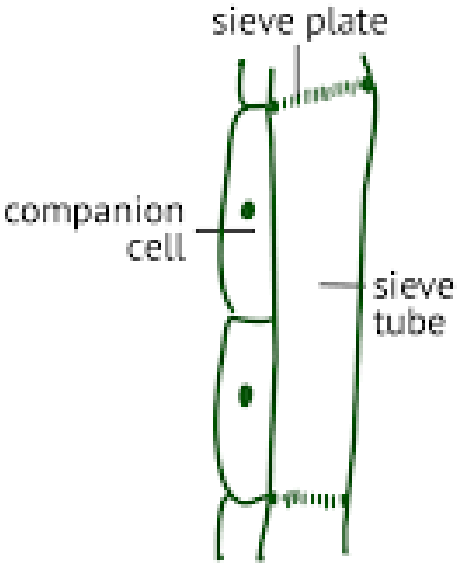
Function:

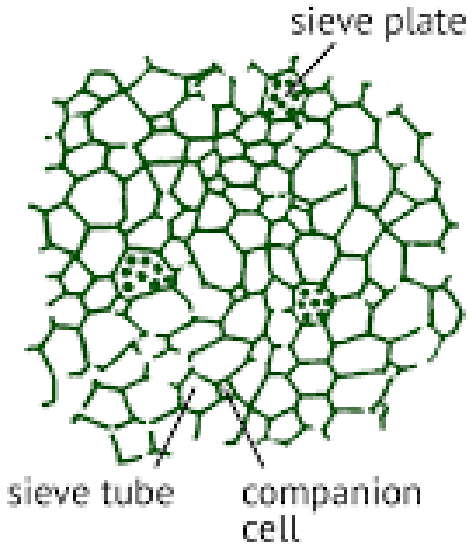
- **Transport of assimilates** (e.g. sucrose, amino acids)
- From **source** = site of synthesis of photosynthetic products
- To **sink** = site where assimilates are stored/used
- Via **translocation**

Different types of cells in **phloem** tissue:

**a) Sieve tube elements**
→ joined end to end to form **sieve tubes**

**b) Companion cells**



# Sieve Tube Elements

- Elongated sieve elements are **joined end to end** Form **continuous column** = **sieve tube**

- Sieve elements are **living cells**

**Structure and how its related to its *function*:**

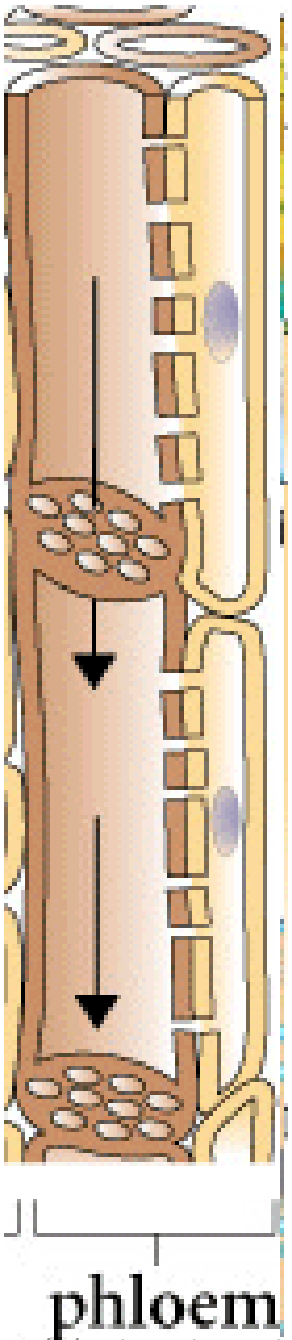
- Have many **plasmodesmata**

→ Allow ***loading of sucrose from companion cells***

→ For ***rapid entry of water*** near source

- **Strong cellulose walls**

→ ***Prevent excessive cell bulging*** under pressure



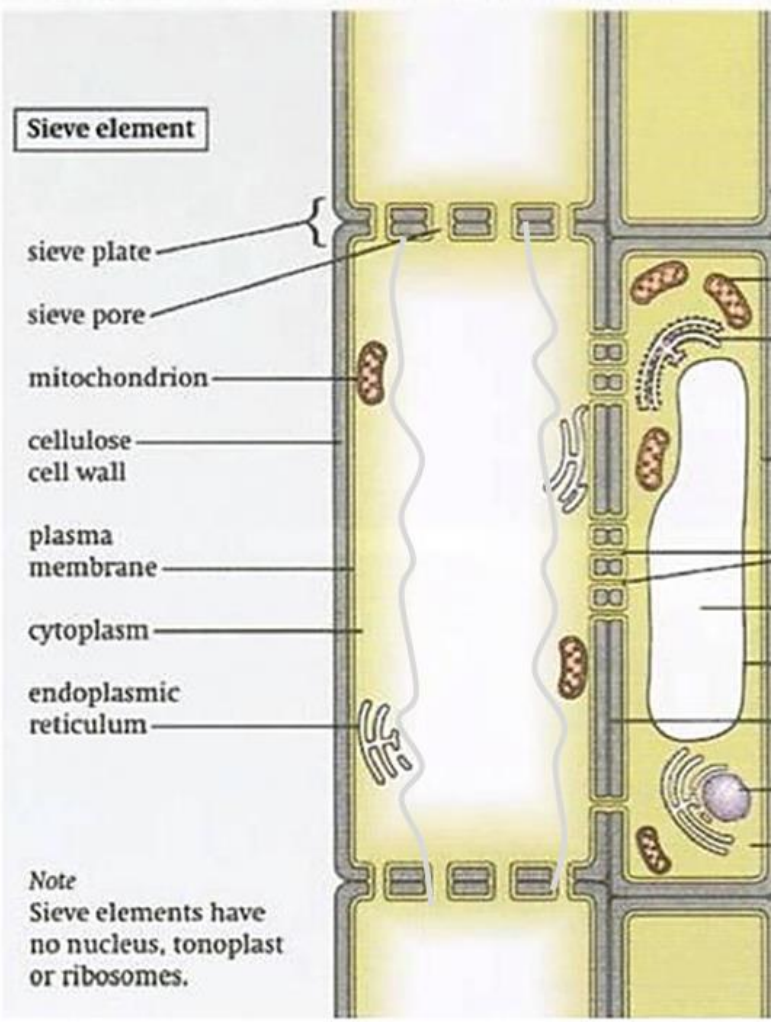
# Sieve Tube Elements

- Has **few organelles**
- Has cellulose cell wall, plasma membrane, few mitochondria and ER only
- Has no nucleus, ribosomes, vacuoles

- Has **peripheral cytoplasm** that lines cell walls

→ ***Less resistance to flow***

→ ***Maximum volume*** of phloem sap containing assimilates transported



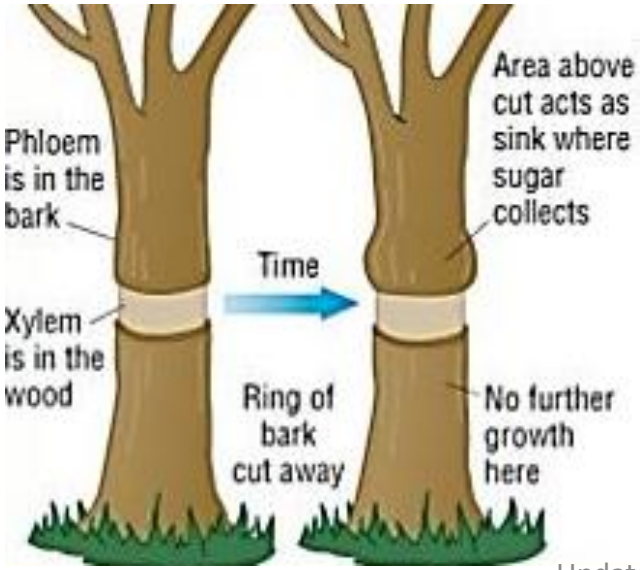
# Sieve Tube Elements

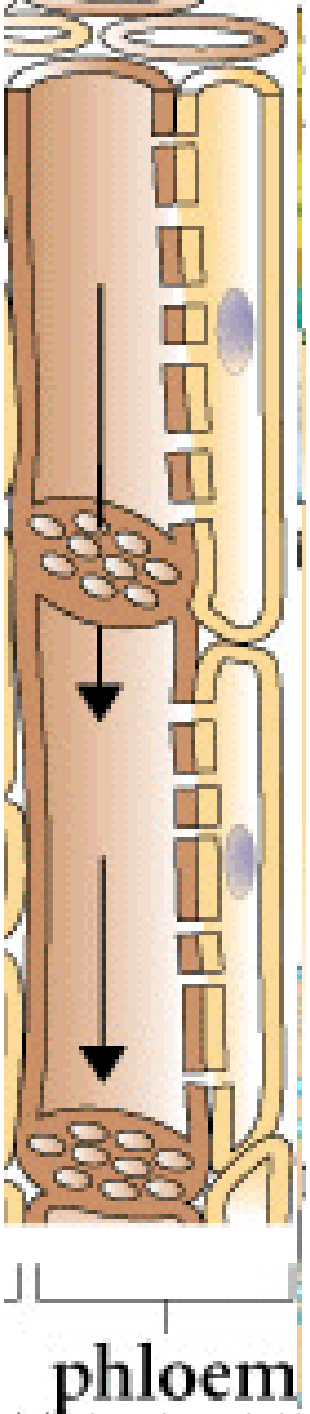
- Have **sieve plate** = perforated cell wall
- Have many **sieve pores**
- Cytoplasm of cells are connected

→ ***Reduce barrier to flow***

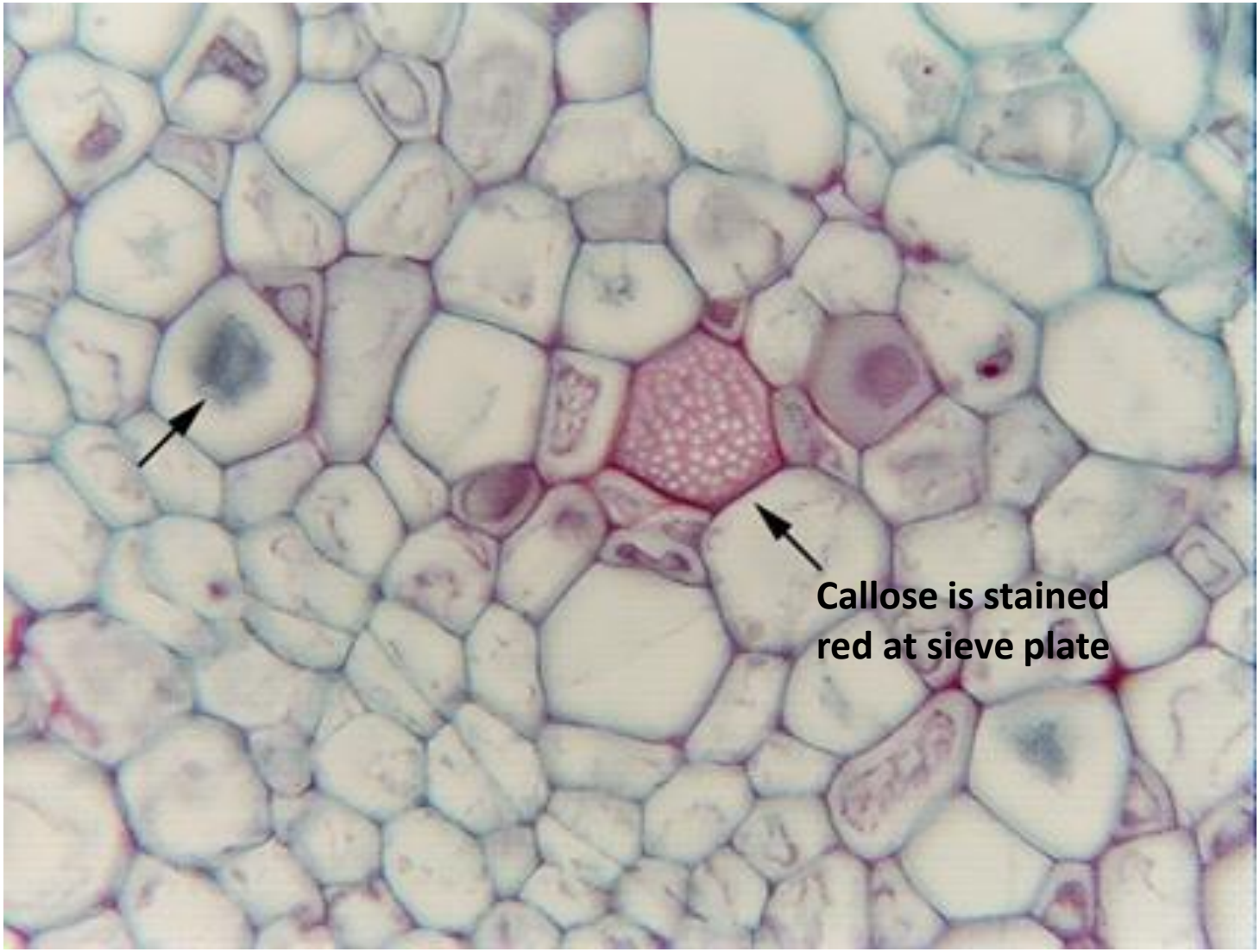
→ ***Prevent cell bulging*** under pressure for phloem

→ Sieve pores become ***plugged with callose to prevent loss of phloem*** sap after damage (a clotting mechanism)


Phloem is in the bark
Xylem is in the wood
Time
Ring of bark cut away
Area above cut acts as sink where sugar collects
No further growth here



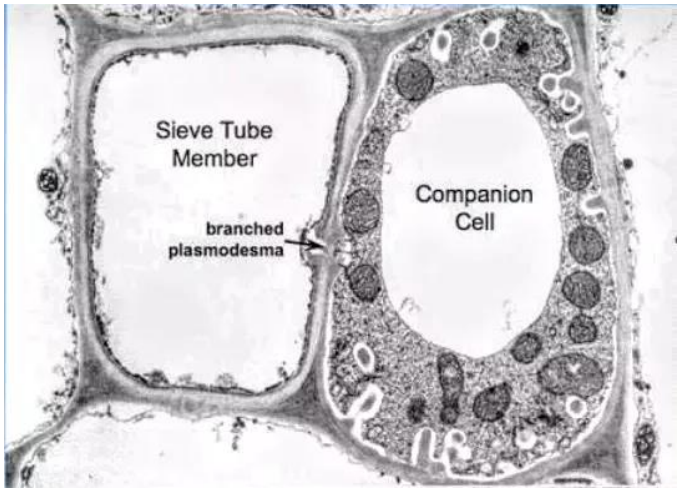
# Sieve Tube Elements



# Companion Cells

- Next to & closely associated with sieve element

**Structure and how its related to its *function*:**




- **Many mitochondria**

→ For ***ATP production*** via aerobic respiration

→ For ***active transport in translocation***

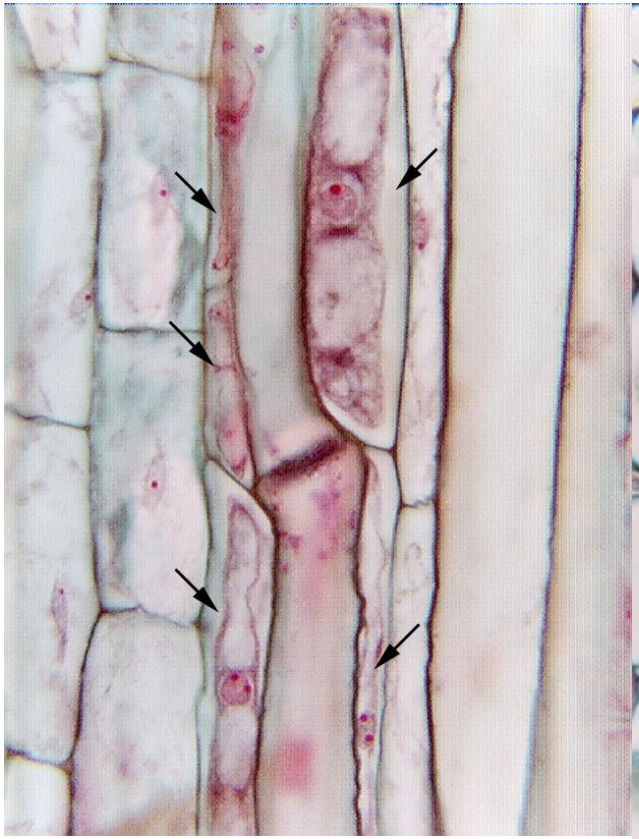
- **Many ribosomes / RER**

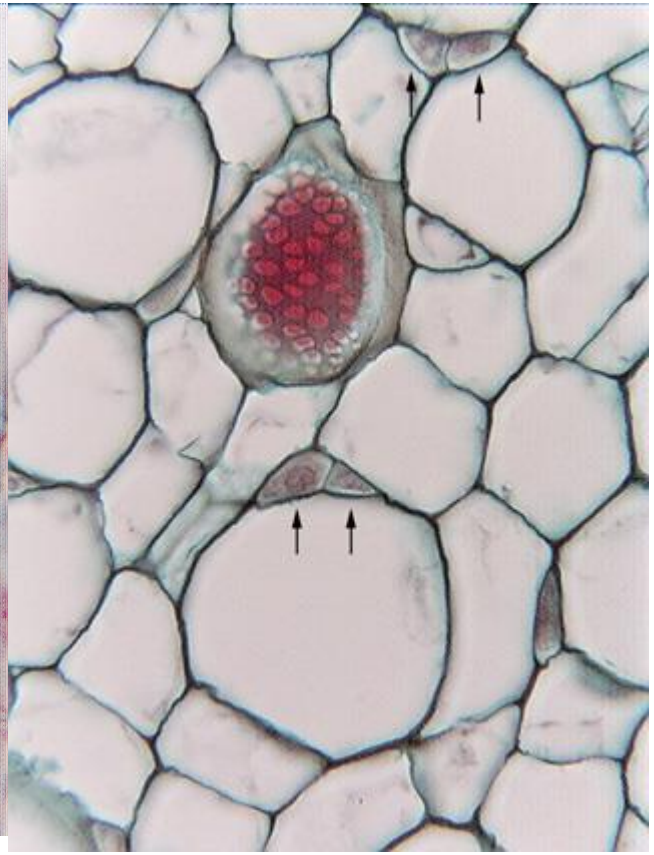
→ For ***polypeptide production***

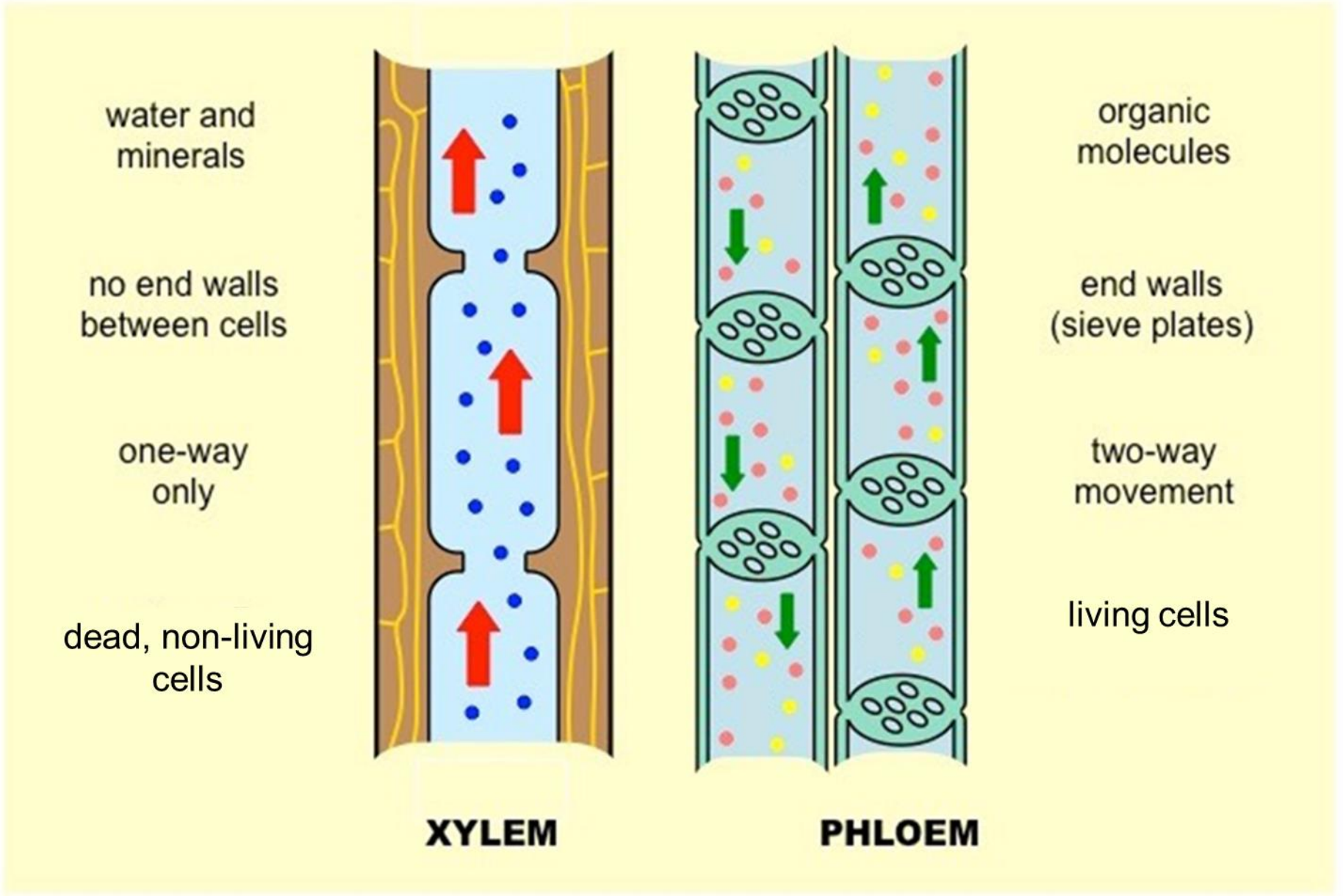
- Numerous **plasmodesmata** across cell walls

→ ***Transport assimilates into sieve tube***

# Companion Cells





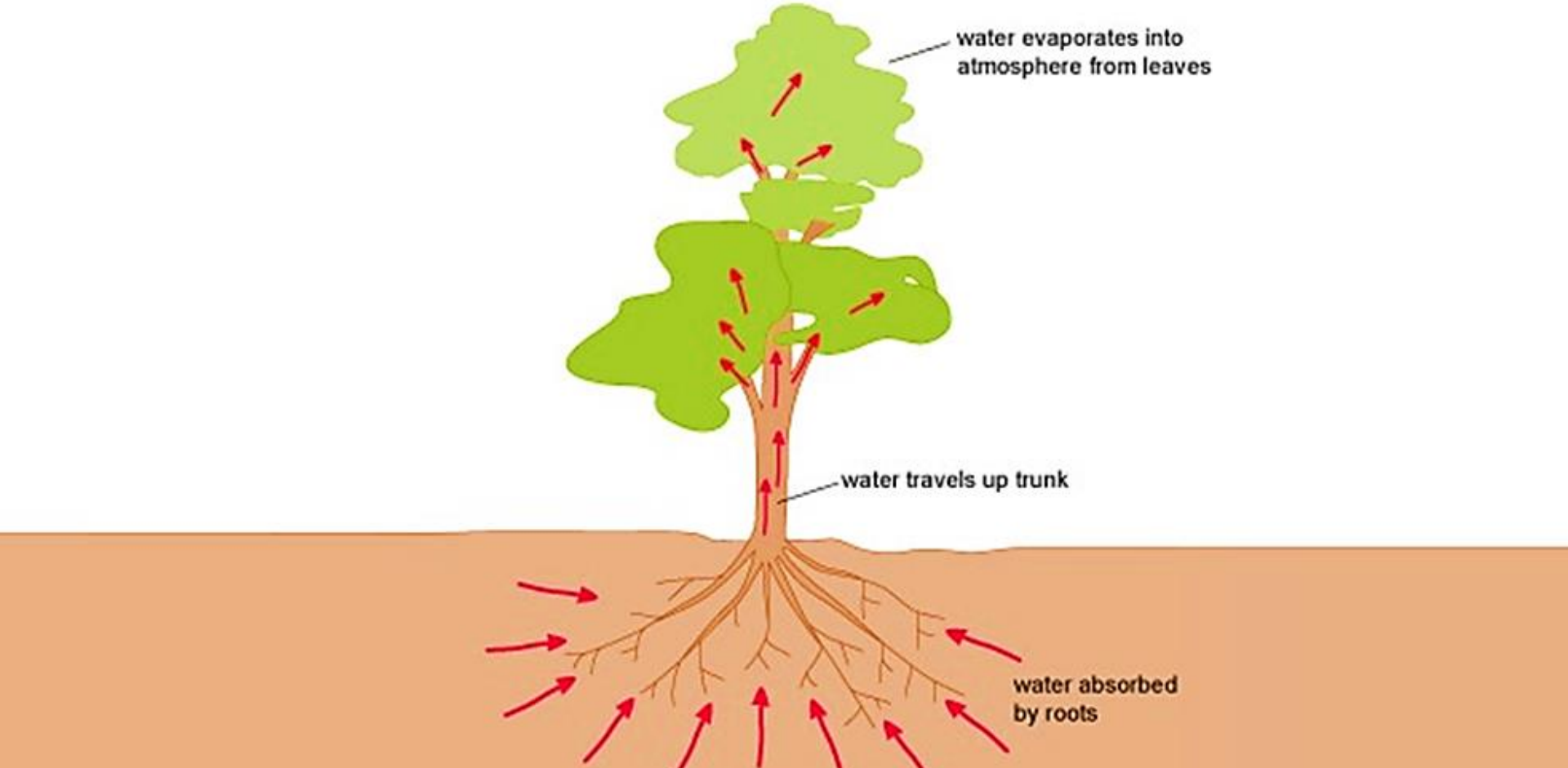

water and minerals
no end walls between cells
one-way only
dead, non-living cells
XYLEM
PHLOEM
organic molecules
end walls (sieve plates)
two-way movement
living cells

Cambridge Assessment International Education

AS Level
Chapter 7

# Transport In Plants

## Transport of Water and Ions



# Introduction to Transport in Plants

**Main substances transported**:

a) Gases (e.g. carbon dioxide, oxygen)

b) Products of photosynthesis (e.g. sucrose)

c) Mineral ions

d) Water

In general, plants have slower transport than animals. Why?

→ Lower requirement for oxygen & glucose

→ Lower energy requirements

→ Lower rate of respiration

# Transport of Gases

- **Using simple diffusion**
- Leaves are thin and flat
- Have branching shape and a network of air spaces

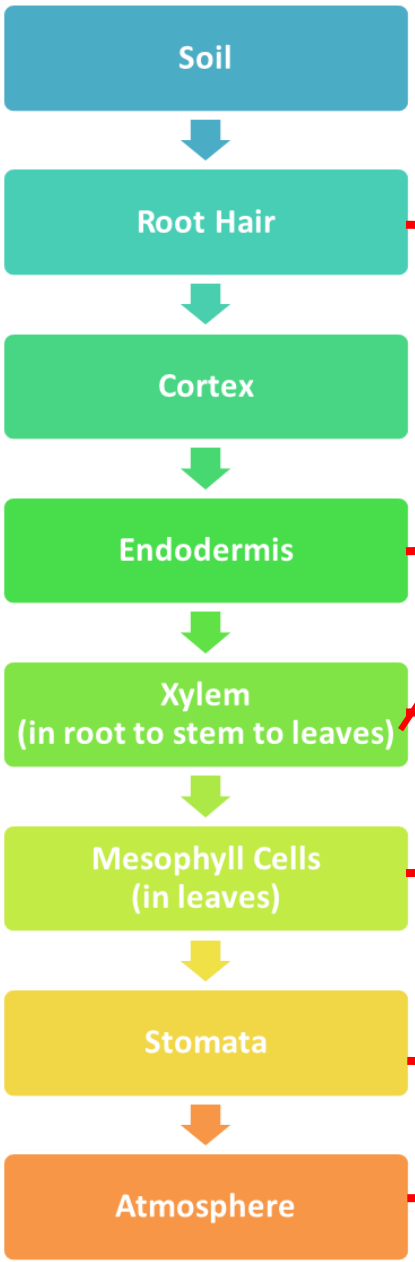
→ **High SA:V ratio**

→ Effective for diffusion

→ No specialized transport system for gases

# Transport of Water and Ions

*always explain in terms of **water potential**




1) Symplastic pathway
2) Apoplastic pathway
   - Casparian strip

Mechanisms for movement of water in xylem vessels
1) Transpirational pull
2) Cohesion and adhesion of water
3) Root pressure

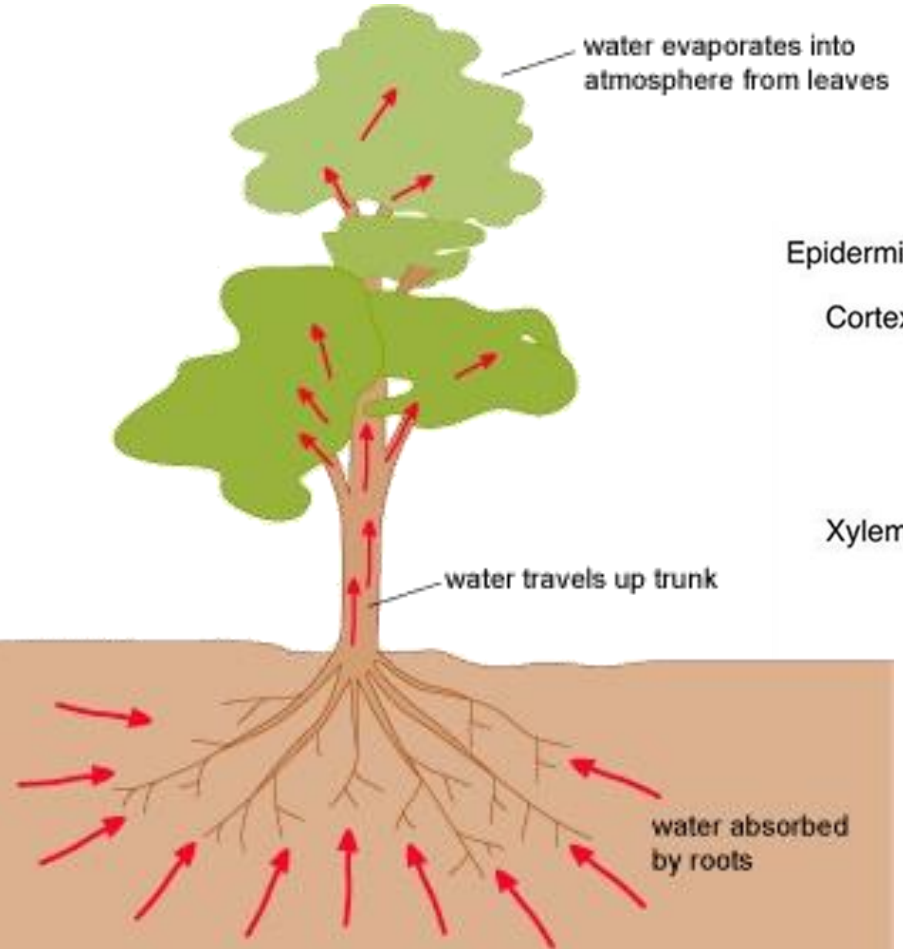
Symplastic/apoplastic pathway to mesophyll cell surface

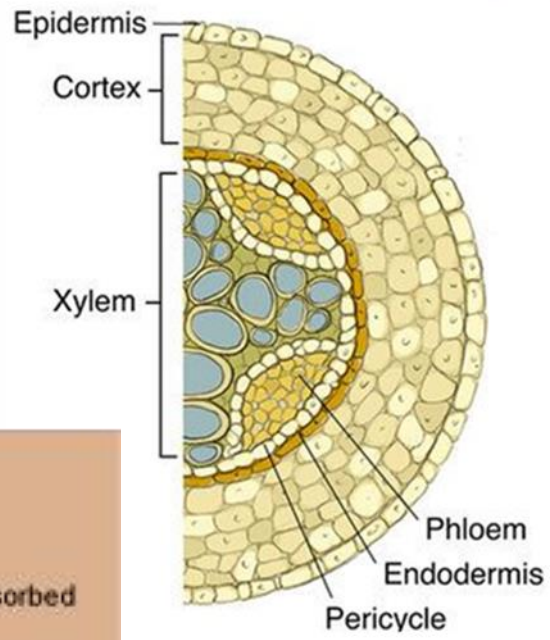
Transpiration
- Factors that affect transpiration rate
- Measuring rate of transpiration using a potometer
- Xerophytes: adaptations to reduce transpiration

Updated on 12/8/21 by Beh SJ @behlogy

# Transport of Water and Mineral Ions

- Similar pathway for both
- From roots upwards




Soil

↓

Root Hair

↓

Cortex

↓

Endodermis

↓

Xylem
(in root to stem to leaves)

↓

Mesophyll Cells
(in leaves)

↓

Stomata

↓

Atmosphere

# Movement of Water From Soil → Root Hairs

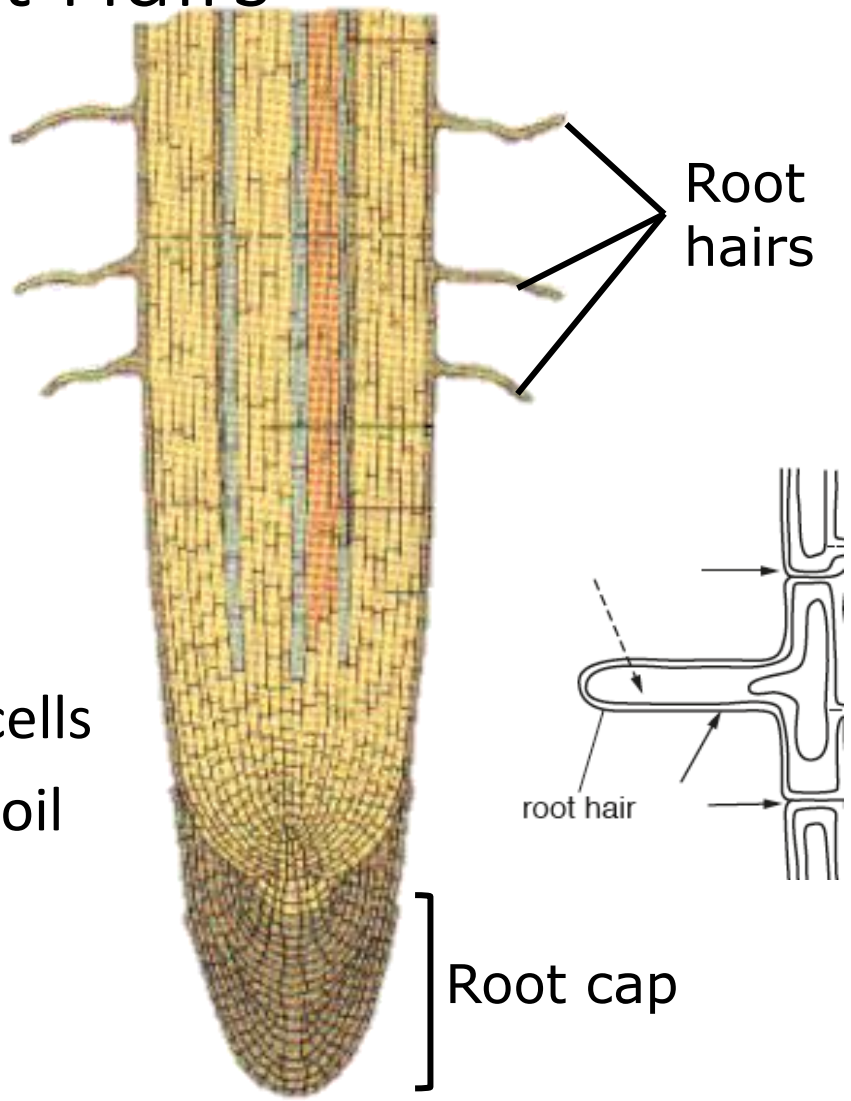
**Root cap:**

- **Impermeable** to water
- Tough – protection

**Root hairs :**

- **Permeable** to water
- Mineral ions taken up by facilitated diffusion / active transport
- Long, thin extensions of epidermal cells
- Able to reach into spaces between soil particles
- Delicate – replaced after a few days
- Large surface area

→increased area of absorption

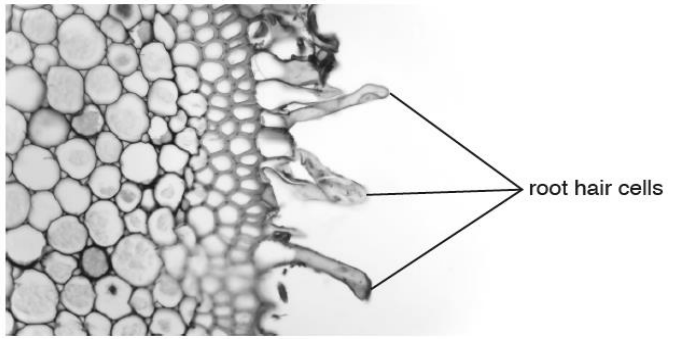


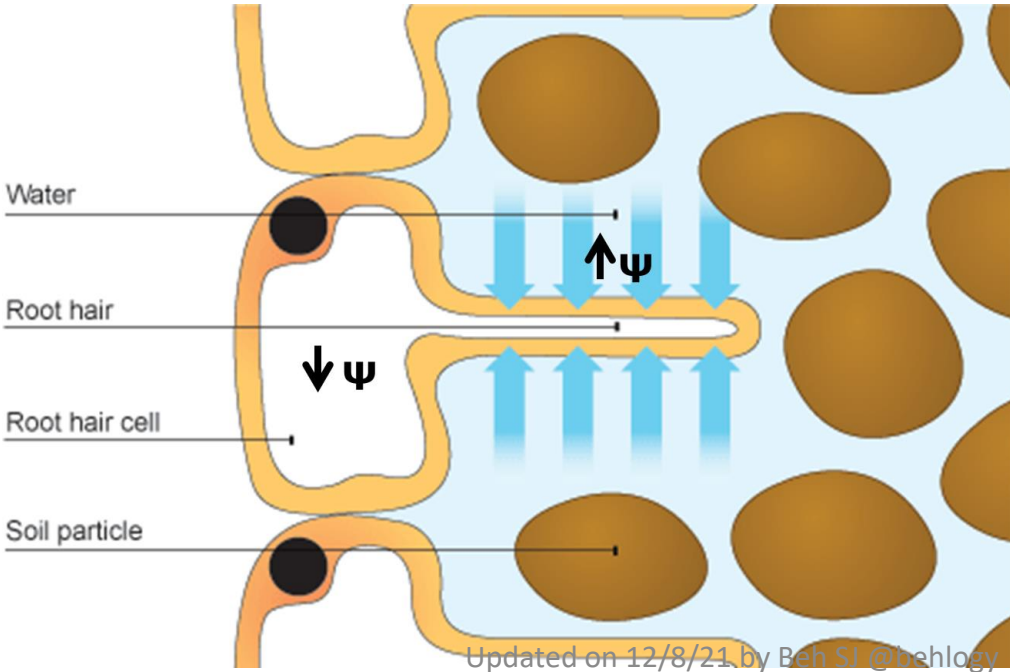
# Movement of Water From Soil → Root Hairs

- **Soil has a higher water potential, Ψ** than root hair's cytoplasm
- Cytoplasm of root hair cell has high concentration of ions and organic substances (proteins, sugars)

- Water diffuses **down water potential gradient** via **osmosis**
- Through the **partially permeable** cell surface membrane

- Into vacuole & cytoplasm of root hair cells

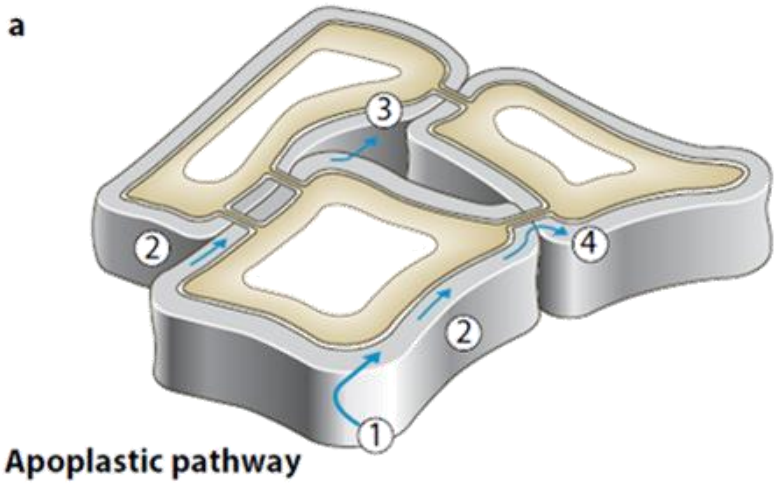


# Movement of Water From Root Hairs → Cortex

- **Root hairs has higher water potential** than cortex
- Water moves down the water potential gradient via **osmosis**
- From root hairs → cortex

**3 possible routes for root hairs → cortex:**




**1) Apoplastic pathway**

- Through **cell wall** or intercellular spaces
- Between **cellulose / lignin** fibres

→ there is adhesion of water to cellulose

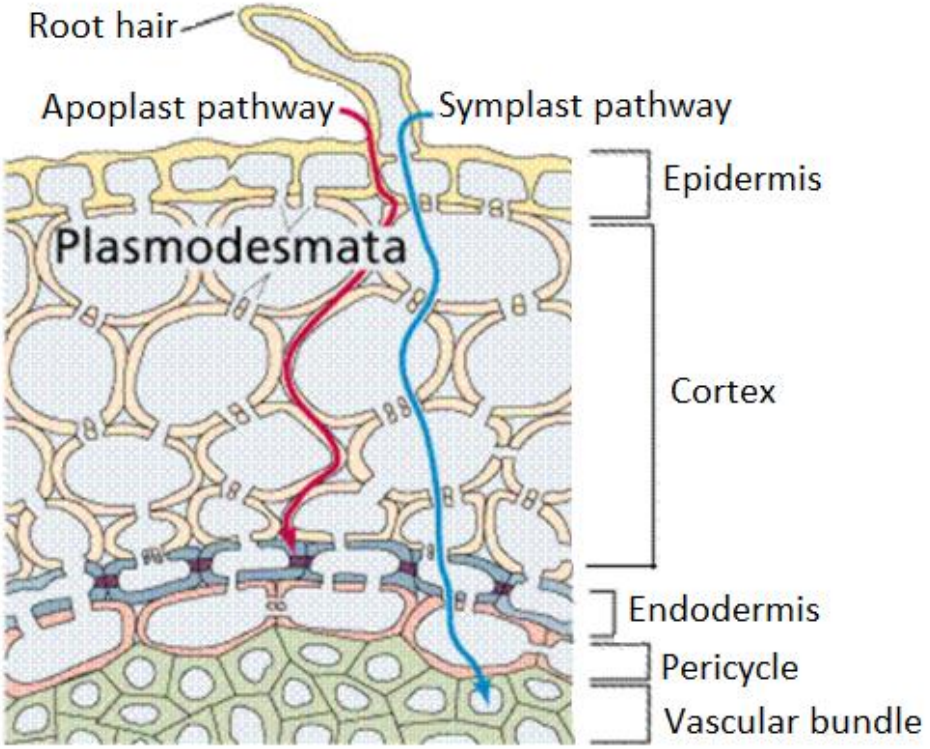
- Water does not cross membranes and enter cells

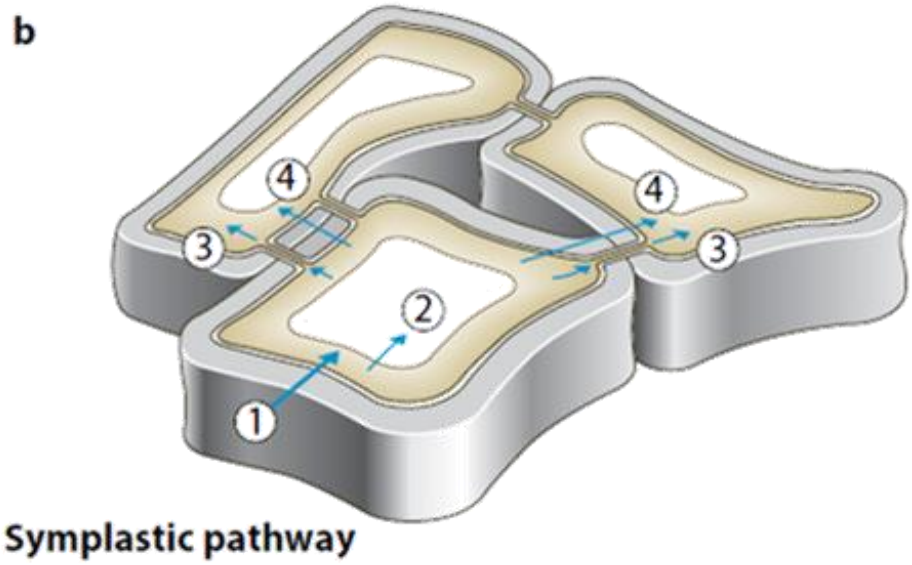
# Movement of Water From Root Hairs → Cortex

## 2) Symplastic pathway

- Through **cytoplasm**
- Travel cell to cell via **plasmodesmata**

## 3) Vacuolar pathway



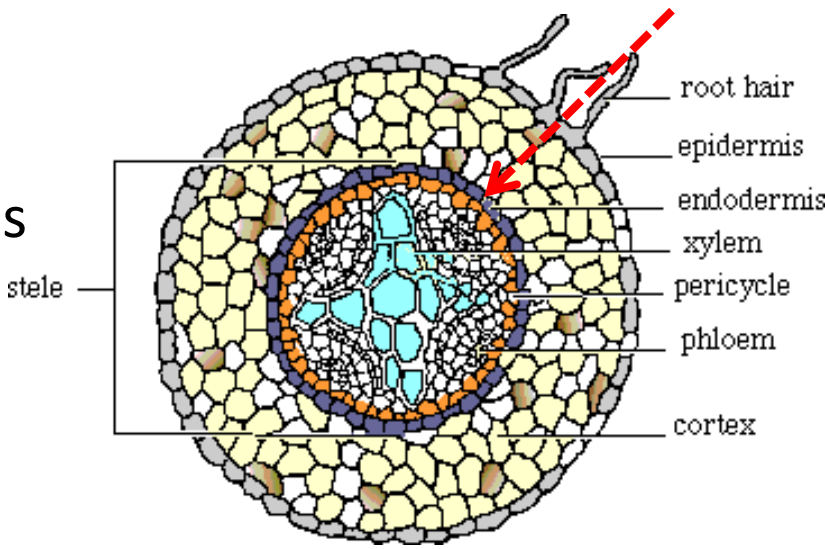



# Movement of Water From Root Hairs → Cortex → Endodermis

The endodermis has a **Casparian strip**
= suberized cell wall

→ Has waxy band of **suberin** in cell walls

→ **Impermeable to water**

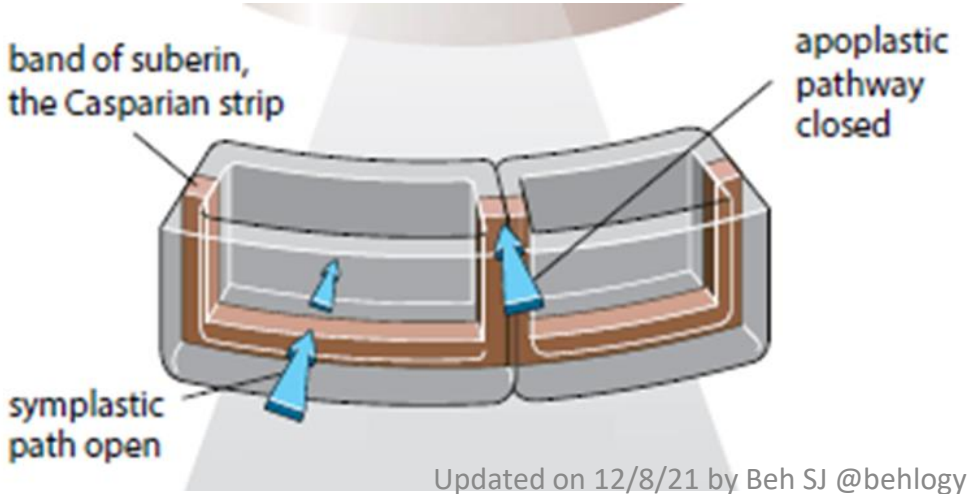



In **endodermal cells**:

→ **Apoplast pathway is blocked**

- Only way to cross endodermis is through cytoplasm

→ **Symplast pathway**



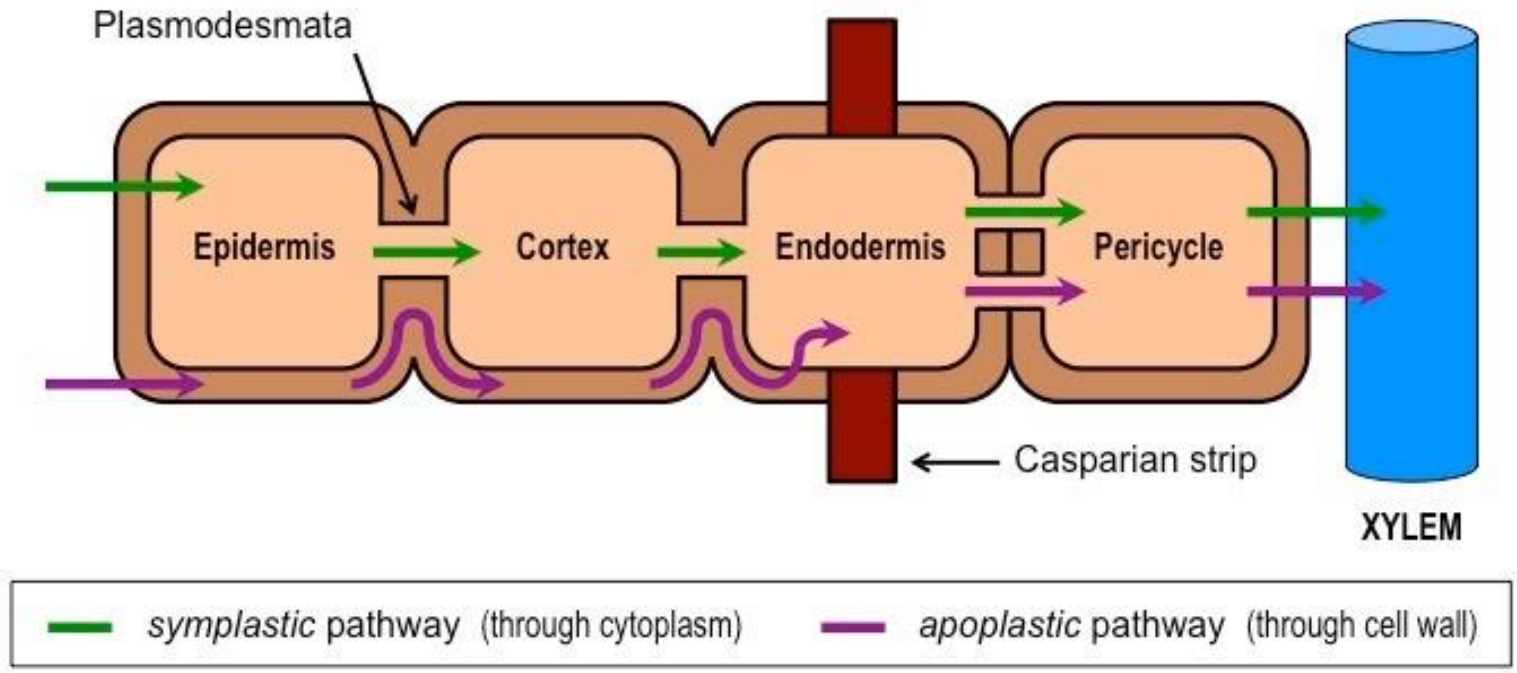
# Movement of Water From Root Hairs → Cortex → Endodermis

- Water and ions must pass through endodermal cells

→ So **transport of mineral ions can be controlled**

→ At carrier proteins of plasma membrane of endodermal cells

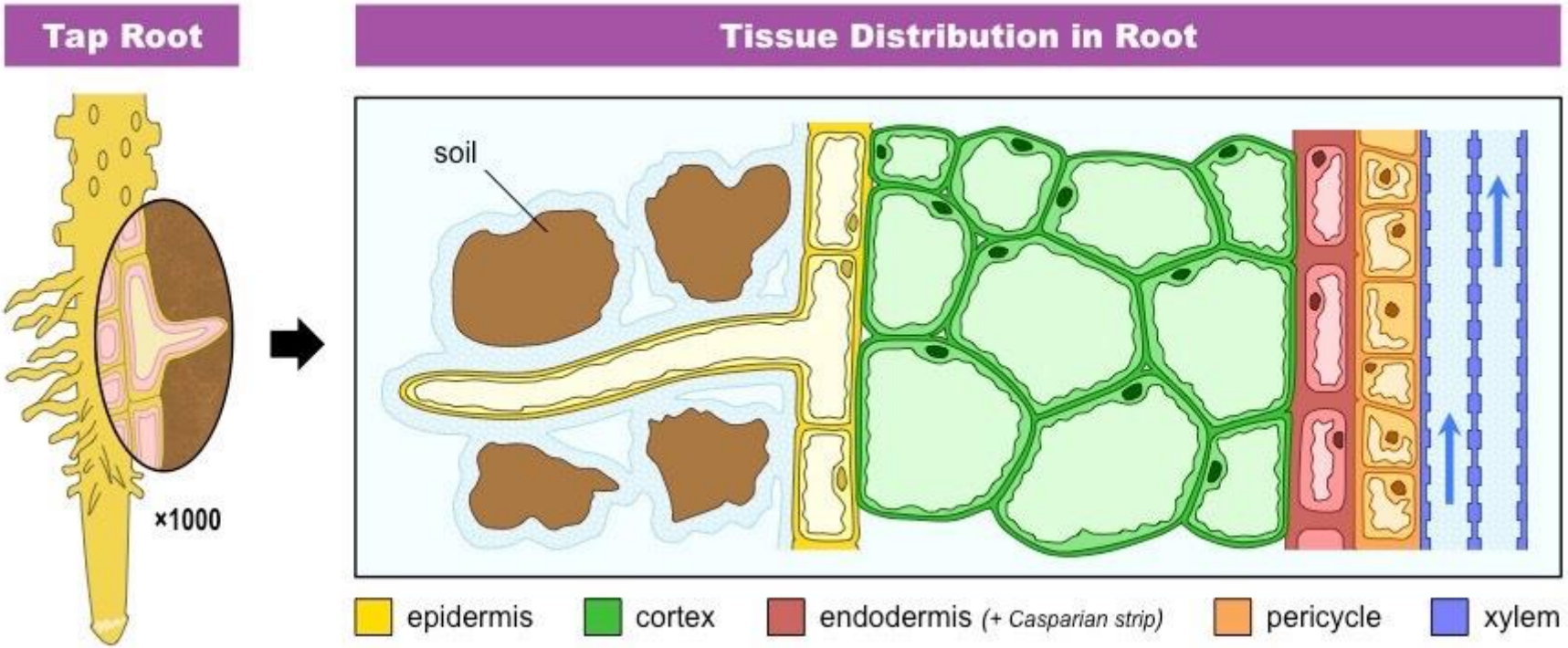
→ Absorbed by active transport and contributes to root pressure



# Movement of Water From Endodermis → Xylem

- Water continues to move **down the water potential gradient**
- Across **pericycle** (layer of cells just below endodermis)

→ **Pits in cell walls of xylem vessels**

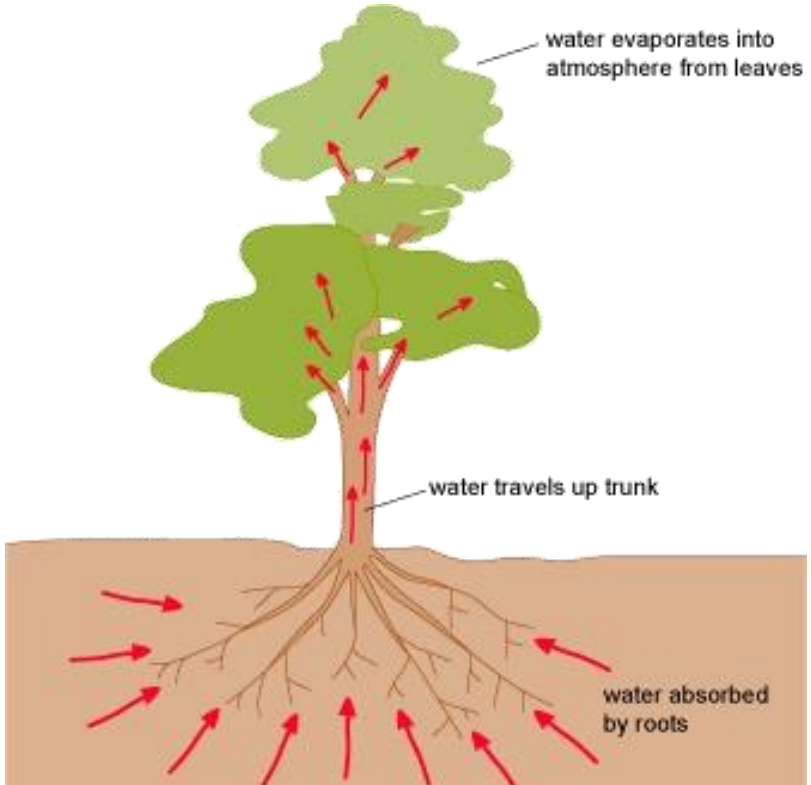


# Movement of Water in Xylem Vessels from Roots to Leaves

- **Roots have a higher water potential** than leaves

→ Water moves down water potential gradient

→ Water moves up xylem from roots to leaves




Soil

↓

Root Hair

↓

Cortex

↓

Endodermis

↓

Xylem (in root to stem to leaves)

↓

Mesophyll Cells (in leaves)

↓

Stomata

↓

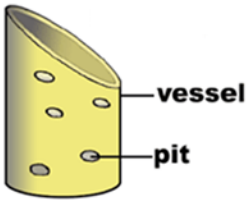
Atmosphere

Updated on 12/8/21 by Beh SJ @behlogy

# Movement of Water from Xylem in Leaves → Atmosphere

- Xylem has a higher water potential than atmosphere
- Water moves **down water potential gradient**

Xylem vessels in leaves → Through pits of xylem vessels → Palisade/spongy mesophyll cells → Onto surface of spongy mesophyll cell walls → Evaporation into air spaces




By either apoplast or symplast pathway

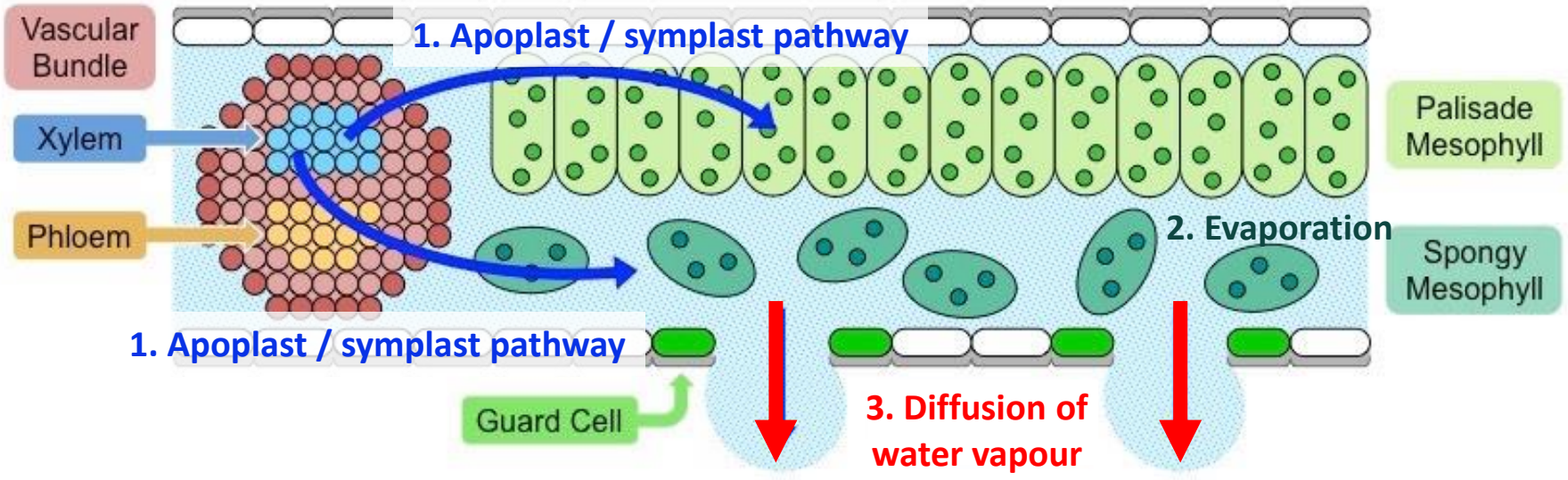
Some water used in photosynthesis

Diffusion of water vapour via stomata to atmosphere

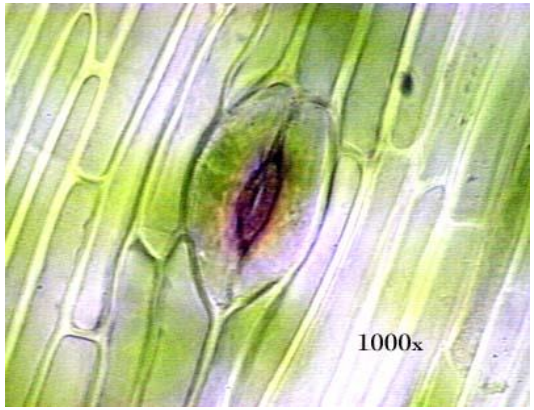
- After evaporation, intercellular airspaces are also saturated with water vapour
- Air space also has higher water potential than atmosphere

# Movement of Water from Xylem in Leaves → Atmosphere

P/S: Do not confuse process names!



# Transpiration




- Loss of **water vapour** from leaves
- Side effect: cooling of plant

2 ways:

**1. Via stomata**

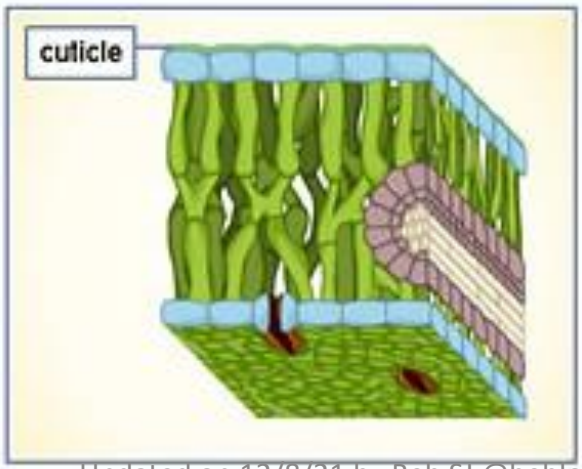
- **Diffusion of water vapour from airspace to atmosphere**
- Only occurs when stomata is open

→ For gas exchange

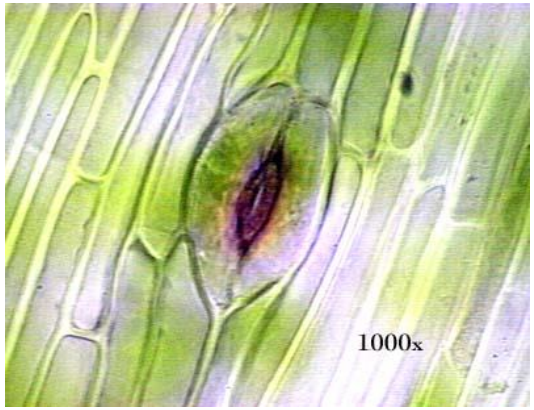
→ Entry of carbon dioxide for photosynthesis and exit of oxygen

**2. Via cuticle**

- Loss of water vapour through cuticle on leaf surface
- Very small amount of water loss



# Transpiration

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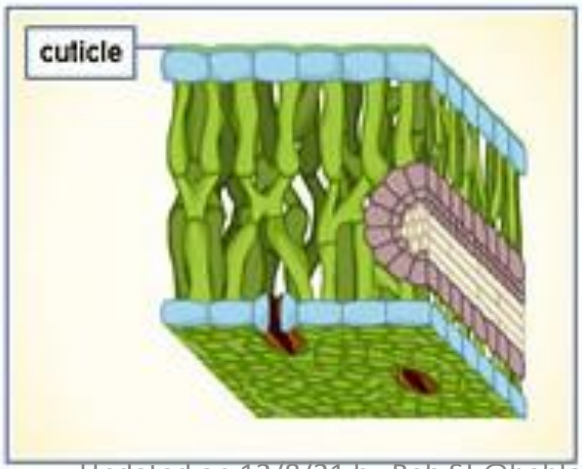
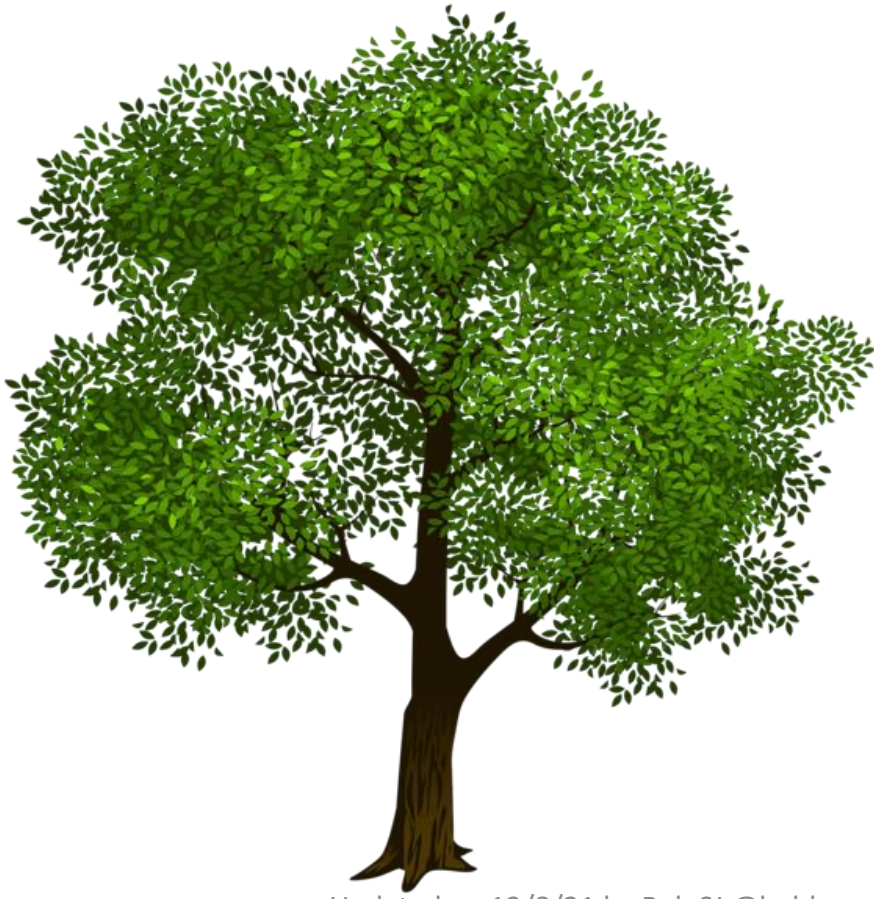


# Q: What helps water to move upwards against gravity without a pump?

**A:**

1) **Transpiration pull** + cohesion and adhesion of water
2) **Root pressure**



# 1) Transpiration Pull, Cohesion and Adhesion

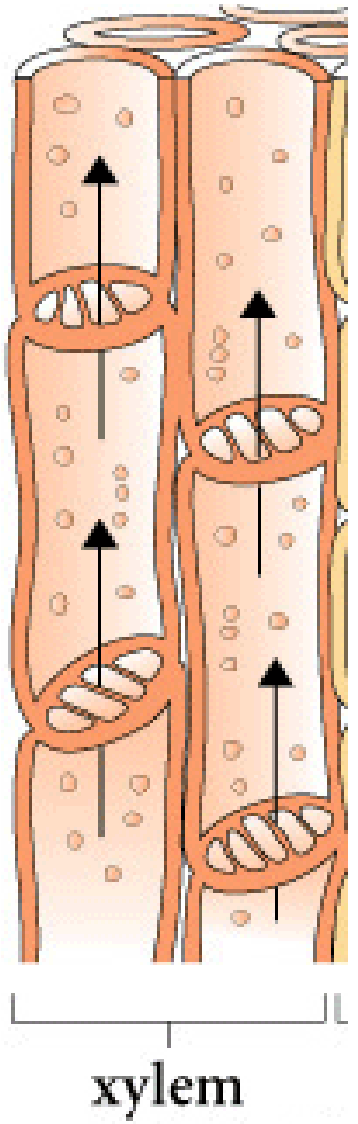
- During transpiration, water vapour diffuse out via stomata
- Water evaporates from mesophyll cell wall surface and **lowers water potential at leaves**

- Roots have a higher water potential than leaves

→ Water moves **down water potential gradient**

→ Water moves up xylem from roots to leaves

- Transpiration from leaves creates **transpiration pull**



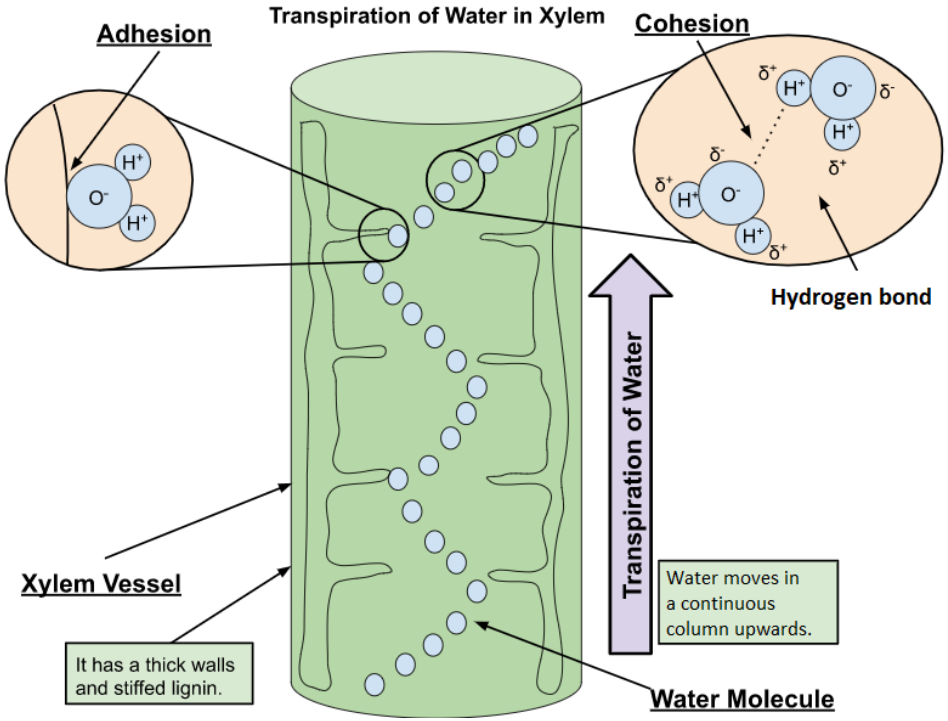
# 1) Transpiration Pull, Cohesion and Adhesion

- **Tension** is set up in xylem vessels due to:

→ **H bonds** between water molecules

→ **Cohesion between water molecules** in xylem and in root cells

→ **Adhesion of water molecules to cellulose** cell wall of xylem vessels

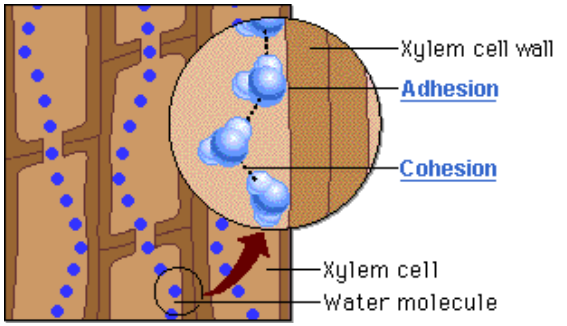


# 1) Transpiration Pull, Cohesion and Adhesion

Result of transpiration pull, cohesion and adhesion:

- This creates a **continuous column** of water

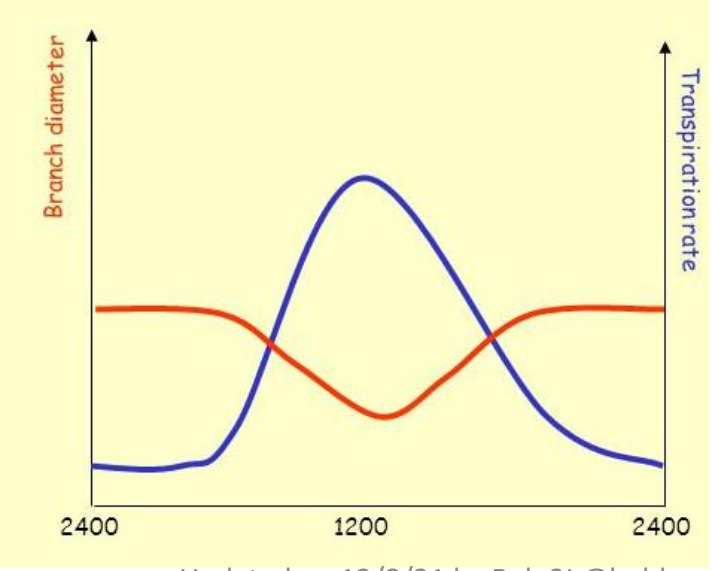
→ Extending from root hairs to stomata in leaves




- Cohesion and adhesion result in **cohesion-tension** in **transpiration pull**

→ Ccause trees to reduce its girth when rate of transpiration is high

- Also capillarity / capillary action = ability of fluid to move upwards against gravity in narrow spaces



# 2) Root pressure

* Not as significant compared to transpiration pull in causing water to move up

- Casparian strip at the endodermis block apoplast pathway

→ So water and ions must pass through endodermal cell

→ **Solutes are actively pumped across membranes into xylem vessels in root**

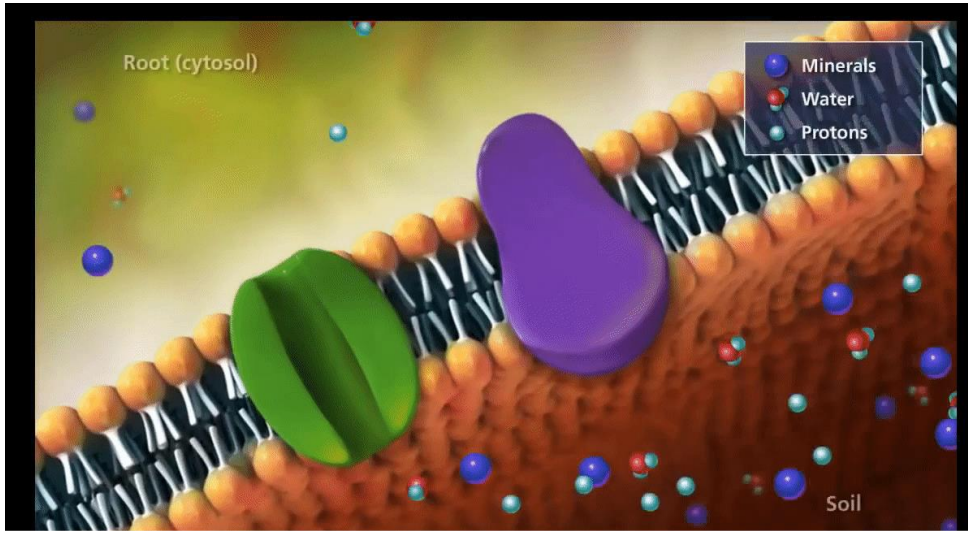
→ This active transport requires ATP

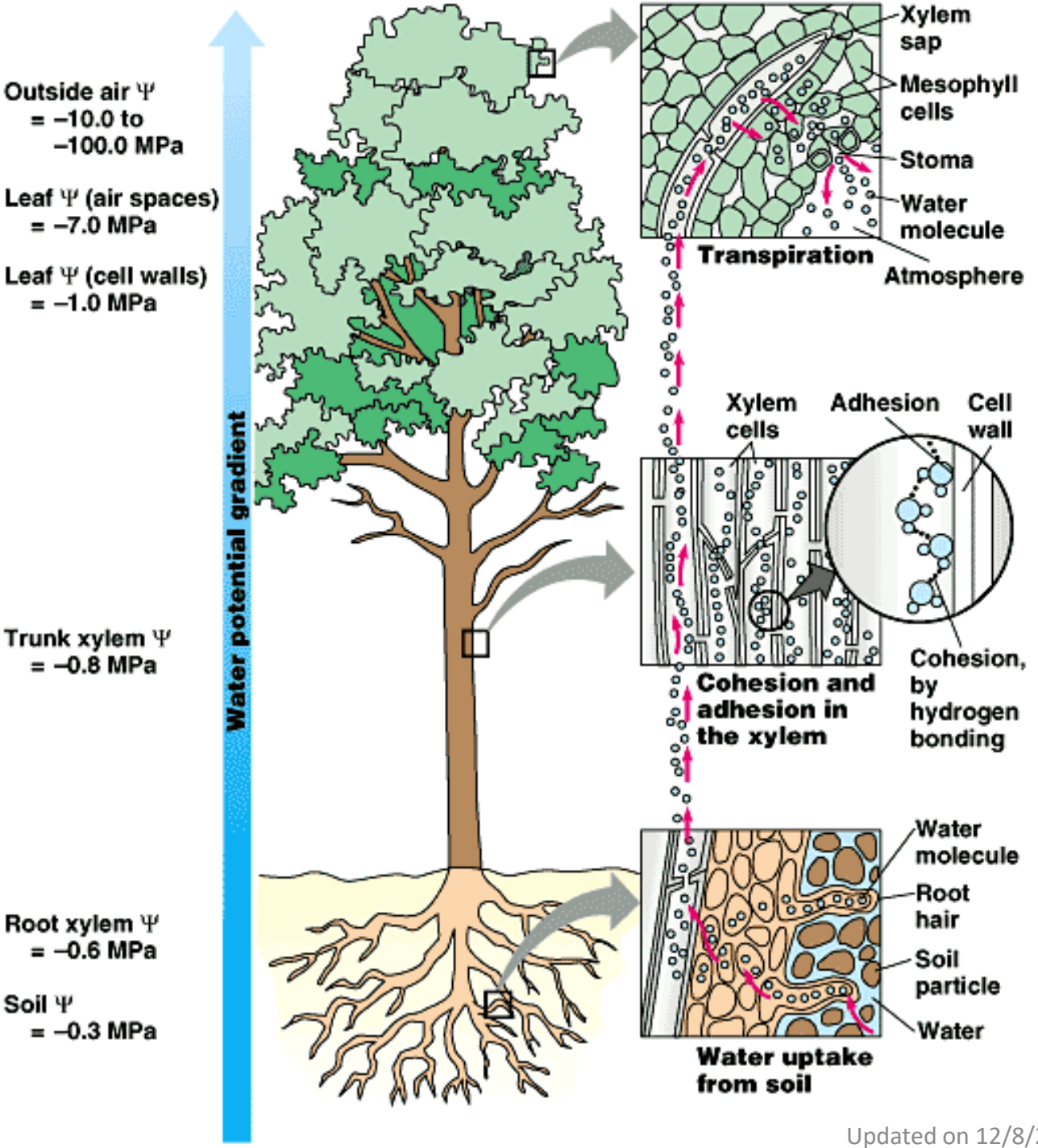
- Xylem vessel in root increases in solute concentration

→ Lowers water potential

→ Results in more water uptake from soil

→ **Increases hydrostatic pressure** at roots




Outside air Ψ
= –10.0 to
–100.0 MPa
Leaf Ψ (air spaces)
= –7.0 MPa
Leaf Ψ (cell walls)
= –1.0 MPa
Trunk xylem Ψ
= –0.8 MPa
Root xylem Ψ
= –0.6 MPa
Soil Ψ
= –0.3 MPa
Water potential gradient
Xylem sap
Mesophyll cells
Stoma
Water molecule
Transpiration
Atmosphere
Xylem cells
Adhesion
Cell wall
Cohesion, by hydrogen bonding
Cohesion and adhesion in the xylem
Water molecule
Root hair
Soil particle
Water
Water uptake from soil

# Rate of Transpiration

**Factors affecting rate of transpiration:**

- **Humidity**

→ At low humidity, ***steeper water potential gradient***

→ High rate of diffusion of water vapour out of stomata

- **Wind speed** / air movement

→ In moving air, water vapour around leaf is blown away

→ ***Steeper water potential gradient***

→ High rate of diffusion of water vapour

- **Water availability**

→ More water available, ***steeper water potential gradient***

→ Reduced water availability causes ***stomata to close***

# Rate of Transpiration

- **Temperature**

→ Rise in temperature, higher kinetic energy

→ Higher rate of ***evaporation*** from surface of spongy mesophyll

→ **BUT** at very high temp, ***stomata closes*** so transpiration slows

- **Light intensity**

→ At high light intensity, increased rate of transpiration bcs ***stomata opens*** more widely due to increased photosynthesis

→ **BUT** at very high light intensity, ***stomata closes*** to prevent loss of water so transpiration (and photosynthesis) slows

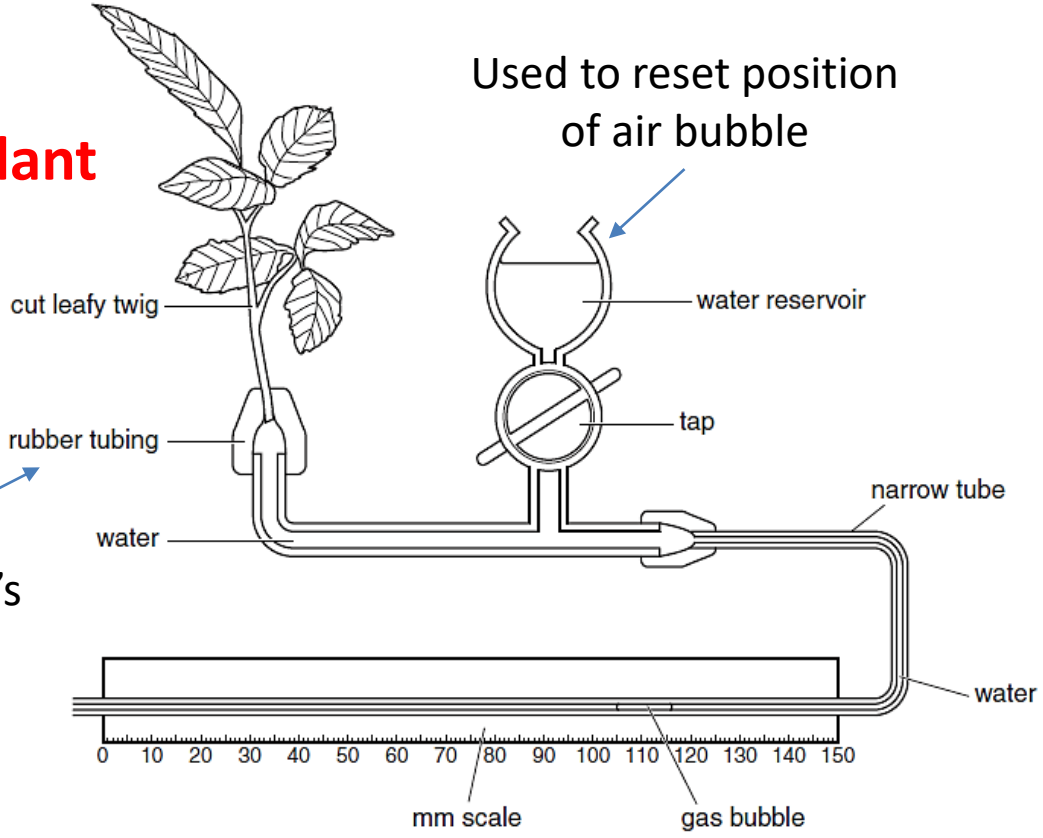
- **Stomatal aperture**

→ Increased width of stomatal aperture allows more water vapour to diffuse out

# How to Measure the Rate of Transpiration?

- Use a **potometer**!

- Assume:
- **Rate of transpiration = rate of water uptake by plant**
- **Only an approximation**, as not all water taken up is used for transpiration



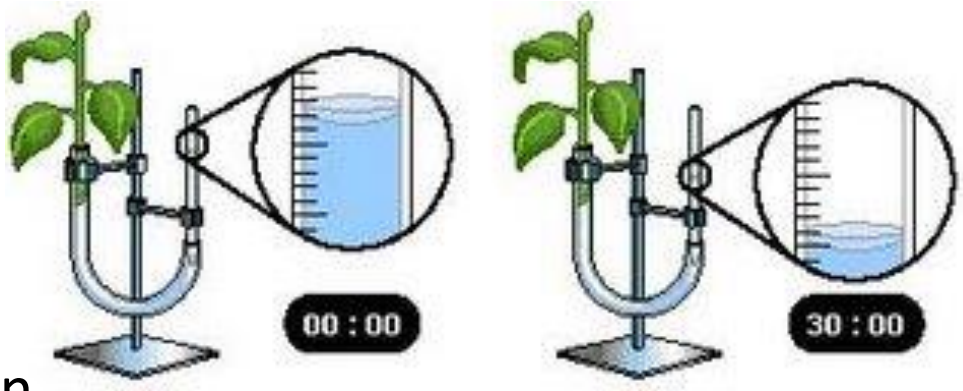
# Potometer

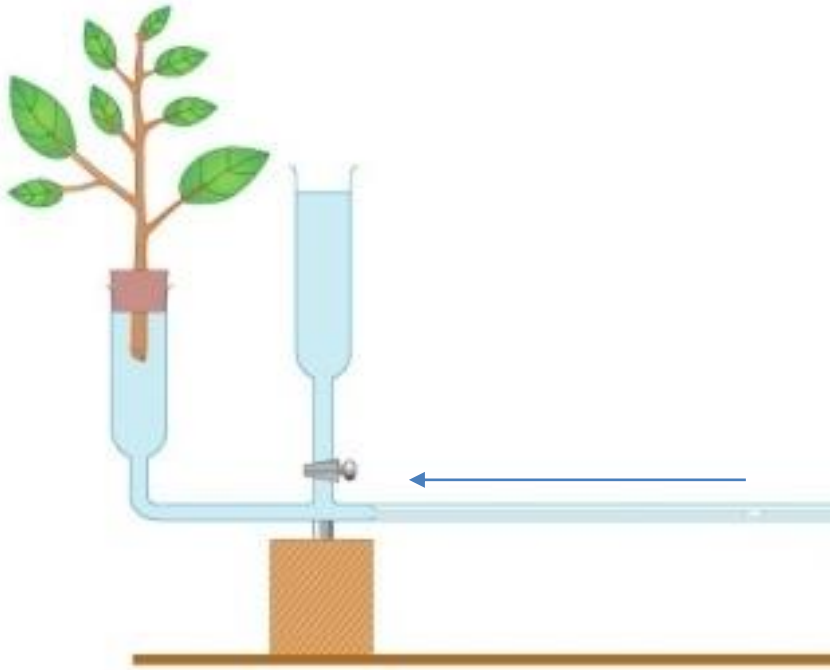
Procedure:

1. Leafy twig cut in a slanted manner

→ Cut underwater to prevent formation of airlock in xylem that will slow down transpiration

2. Twig is put into a potometer
3. Expose to different sets of conditions for a set time
4. Measure rate of air bubble movement / rate of water loss



# Xerophytes

- Plants living in places
- With **short supply of water**
- Which have **special structural adaptations**

→ To **reduce water loss**

Examples of xerophytes:

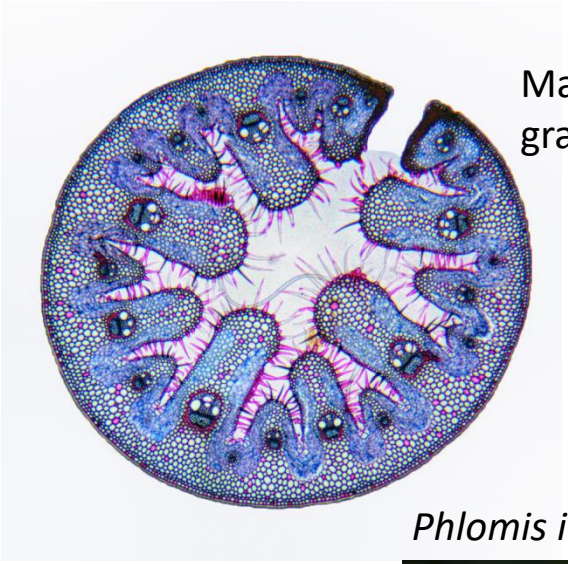
- Marram grass
- Cactus
- Sitka spruce
- *Phlomis italica*
- Cardon

# Special Adaptations

1. **Rolled leaves**

- Exposing tough, waterproof cuticle to the outside air
- Stomata enclosed in humid space within the rolled leaves

→Reduce water potential gradient between air space and atmosphere



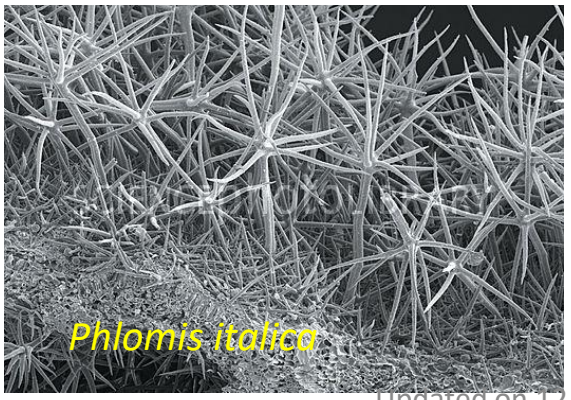
Marram grass

*Phlomis italica*

2. **Hairs / Trichomes**

- In folded inner surface
- Trap water vapour / layer of moist air near leaf surface

→ Reduce water potential gradient between air space and atmosphere



# Special Adaptations

3. **Sunken stomata**
- Minimise effect of wind
- Traps layer of moist air

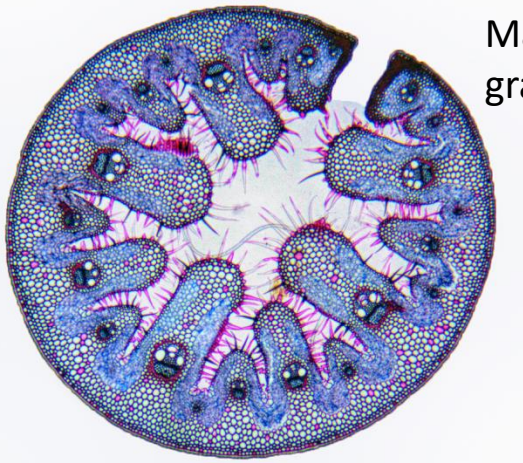
→ Reduce water potential gradient between air space and atmosphere

4. **Stomata only present on lower/inner surface**

→ Shaded, so reduces evaporation

- Surface directly exposed to air currents has no stomata

5. **Reduced no. of stomata**



Marram grass

Sitka spruce

# Special Adaptations

6. **Leaves reduced to spines / needles / small leaves**

→ Reduces surface area for transpiration

→ Also added protection against animals

Cactus

Cardon

Sitka spruce

# Special Adaptations

7. **Thick waterproof, waxy cuticle**

- Increased distance decreases rate of diffusion
- Reduced water loss through cuticle

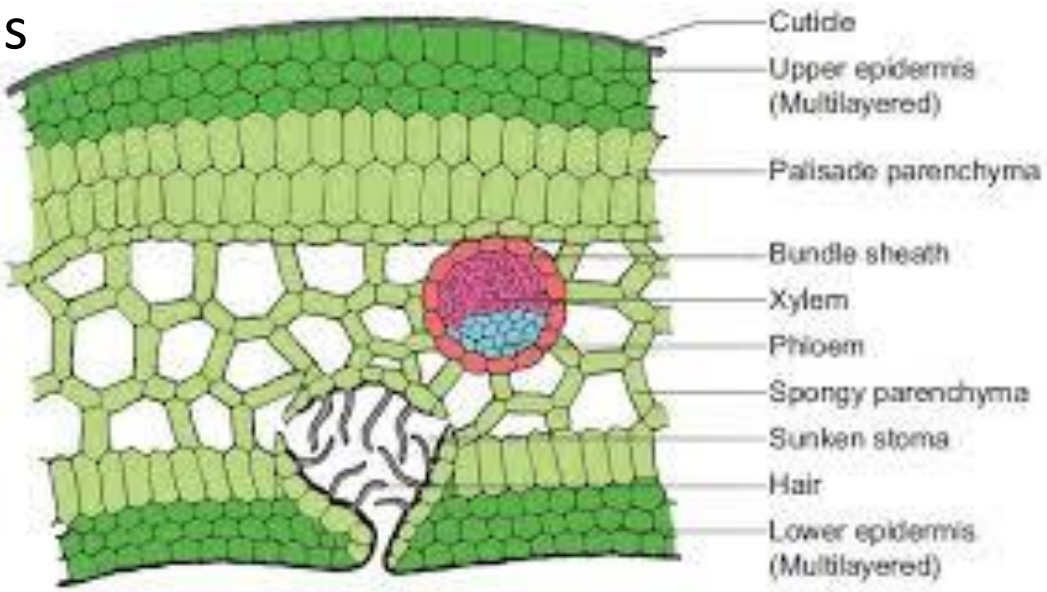



Figure 9.15: T.S. of *Nerium* Leaf

- Waxy, reflects some light
- Reduces heat load and evaporation

8. **Multilayered epidermis**

- Increase distance for diffusion of water vapour to cuticle

# Other Adaptations to Gain More Water

- Stems that store water

→ Swollen, succulent cardon stems

- Flattened, photosynthetic cactus stems

- Deep and extensive roots

Cactus

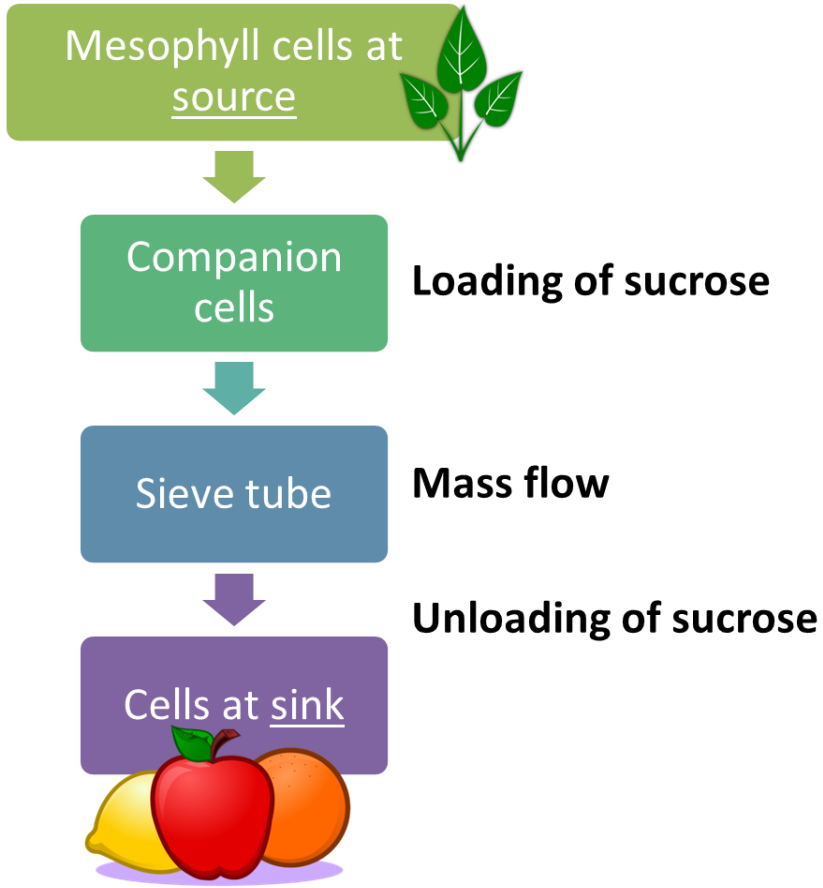
Cardon

Cambridge Assessment International Education

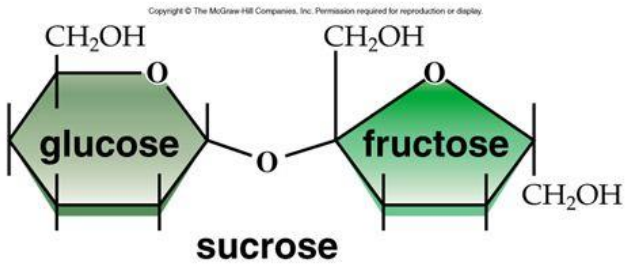
AS Level
Chapter 7

# Transport In Plants

## Translocation of Sucrose



# Translocation

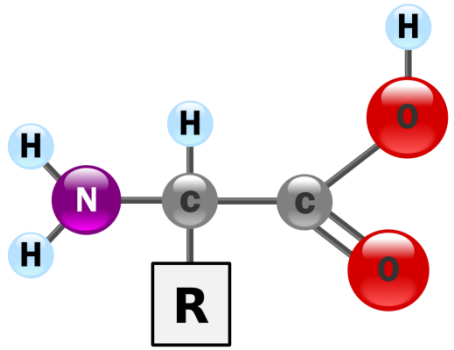



- Transport of **assimilates** within plants

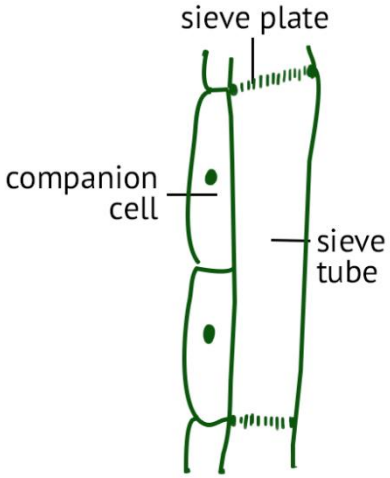
→ Soluble, organic substances

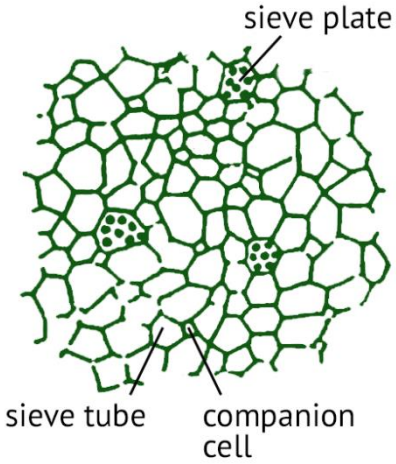
→ Made by plant via photosynthesis

→ E.g. sucrose, amino acids




- Transported as phloem sap in phloem tissue



# Source → Sink

**Source:**

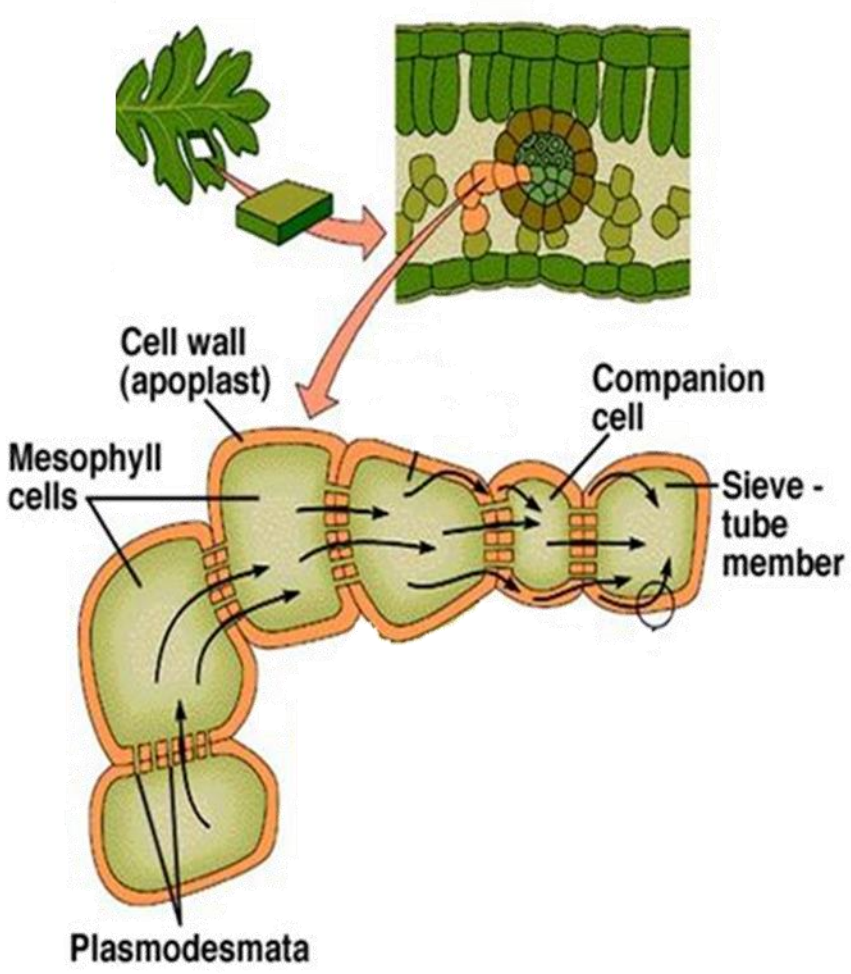
- **Site of synthesis of photosynthetic products**
- **Loading of sucrose** into sieve tube here
- E.g. Mesophyll cells of leaves

**Sink:**

- **Site where assimilates are stored/used for growth**
- **Unloading of sucrose** from sieve tube here
- E.g. Roots, fruits, tubers
- Can be below / above source

- Phloem sap **able to flow upwards or downwards** in a sieve tube
- But one way direction in 1 sieve tube at any 1 time

# Mesophyll cells → Mesophyll cells near sieve tubes




- **Photosynthesis** occurs in mesophyll cells

→ Produce glucose

→ Converted into sucrose

- Transport of sucrose from mesophyll cells to mesophyll cells nearer to phloem via:-

1) **Symplast pathway**
2) **Apoplast pathway**

# Loading of Sucrose into Sieve Tubes

- **Active transport** involved

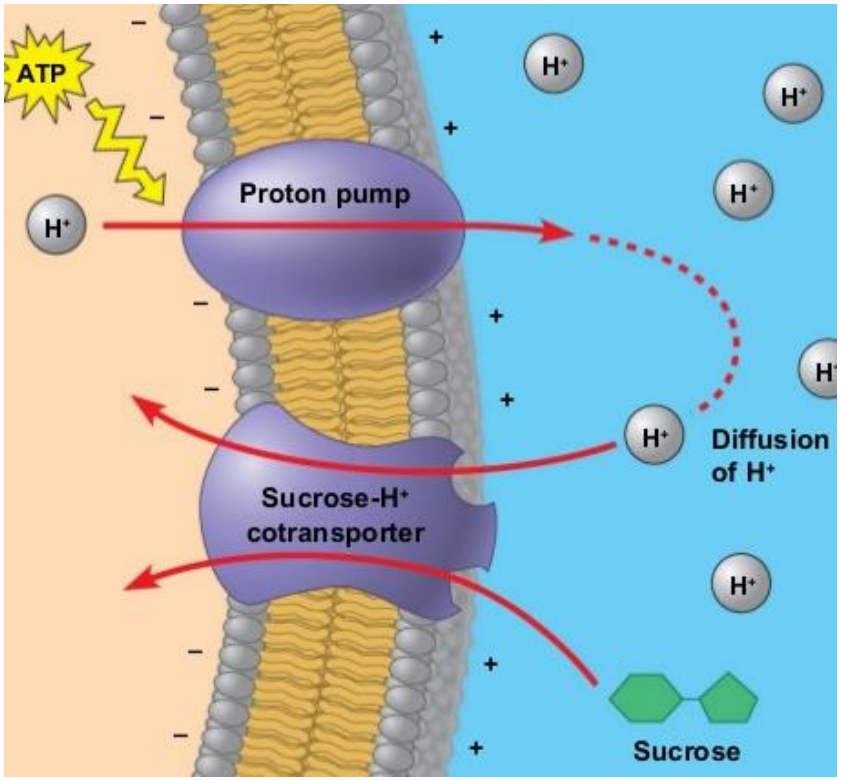
→ Requires ATP

- **$H^+$ ions** in companion cells are **pumped out**

→ Into **mesophyll cell wall** / intercellular space

→ By a proton pump

- **$H^+$ ions gradient builds up**



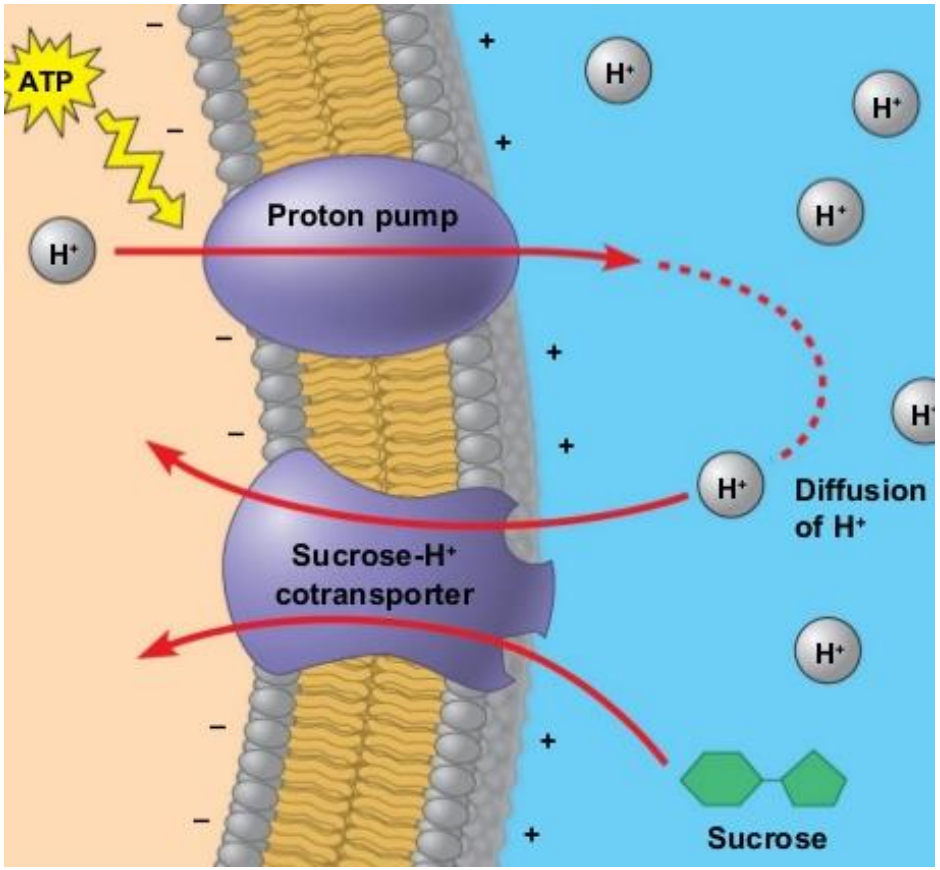
# Loading of Sucrose into Sieve Tubes

- **$H^+$ ions re-enter companion cells *down*** conc. gradient

→ using the **sucrose/$H^+$ co-transporter protein**

→ Sucrose is cotransported together into companion cell ***against*** conc. gradient

- $H^+$ ions is transported via facilitated diffusion
- Sucrose is transported via secondary active transport

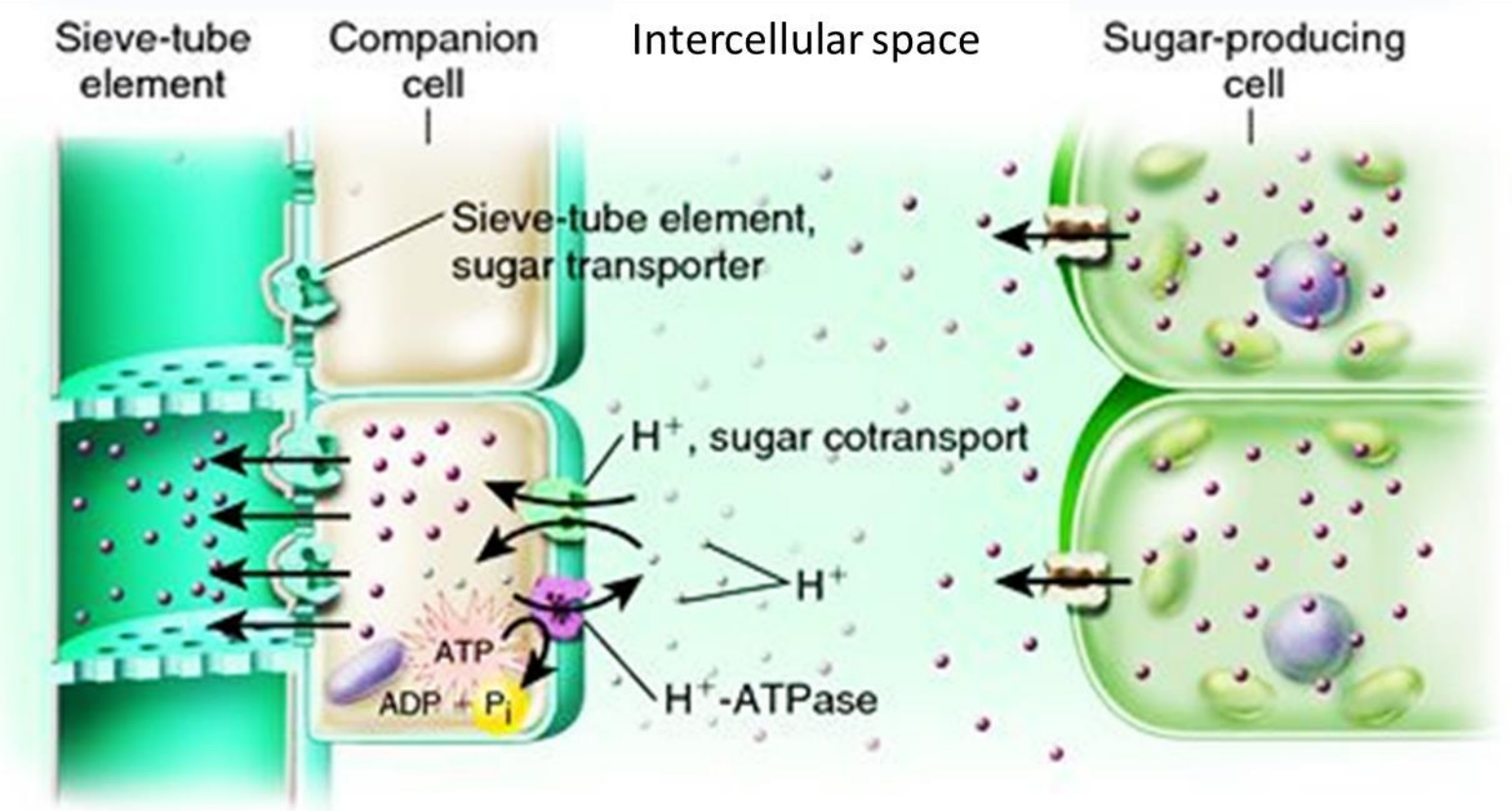


# Loading of Sucrose into Sieve Tubes

- **Sucrose diffuse** from companion cell **into sieve tube**

→ Down the concentration gradient

→ Via plasmodesmata



# Translocation in Sieve Tubes

**Near source:**

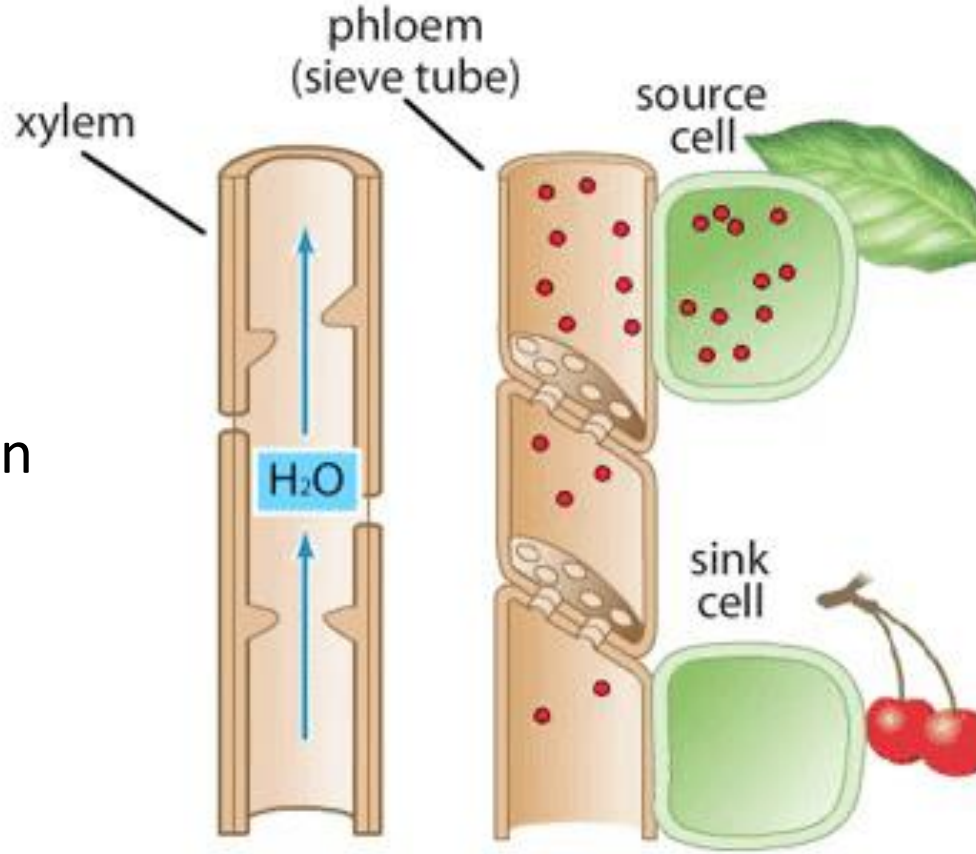
→ Presence of sucrose **lowers water potential** in sieve tube element

→ **Water enters** sieve tubes via **osmosis**

→ **Down water potential gradient**

→ **Increases hydrostatic pressure** in sieve tube near source

(think of this as a "push")



# Translocation in Sieve Tubes

**Near sink:**

- **Lower hydrostatic pressure in sink**

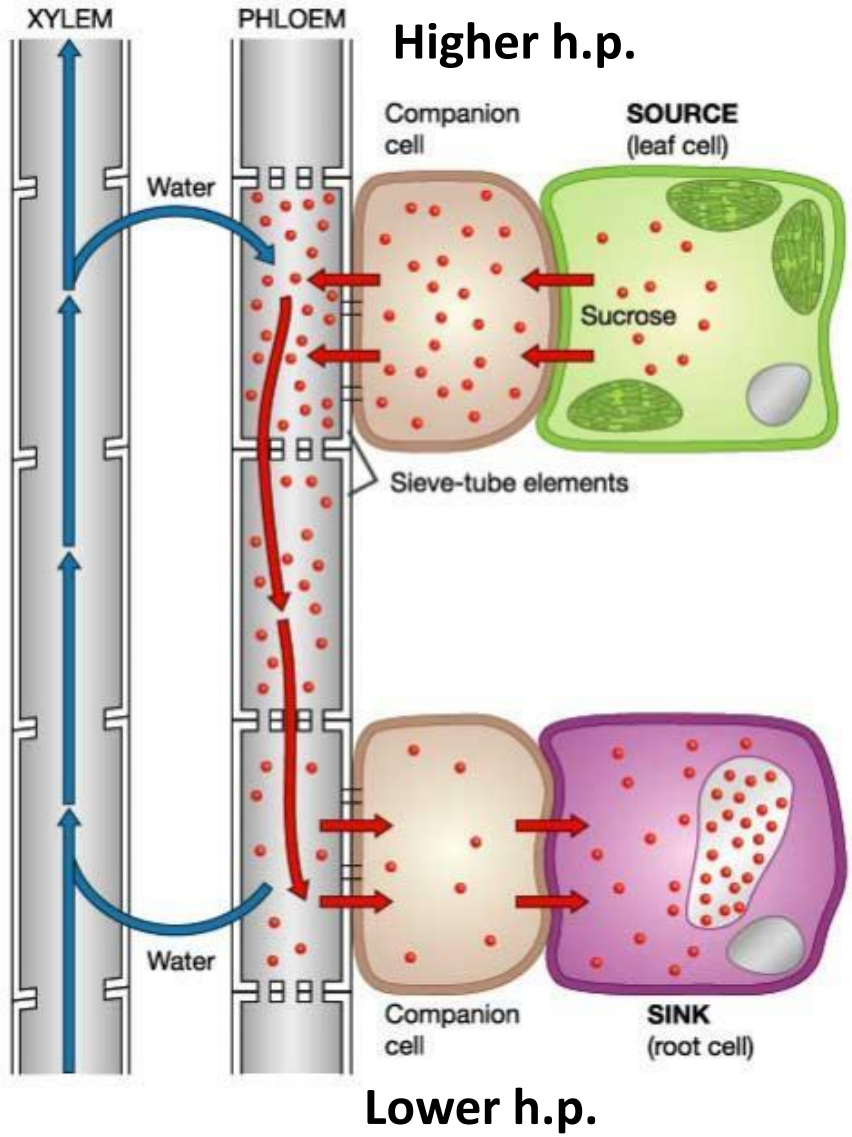
→ Due to **removal of sucrose**

- Phloem sap with sucrose move from region of high to low hydrostatic pressure

→ **Down hydrostatic pressure gradient**

→ Towards sink

- Result in **mass flow** = movement of fluids down a hydrostatic pressure gradient

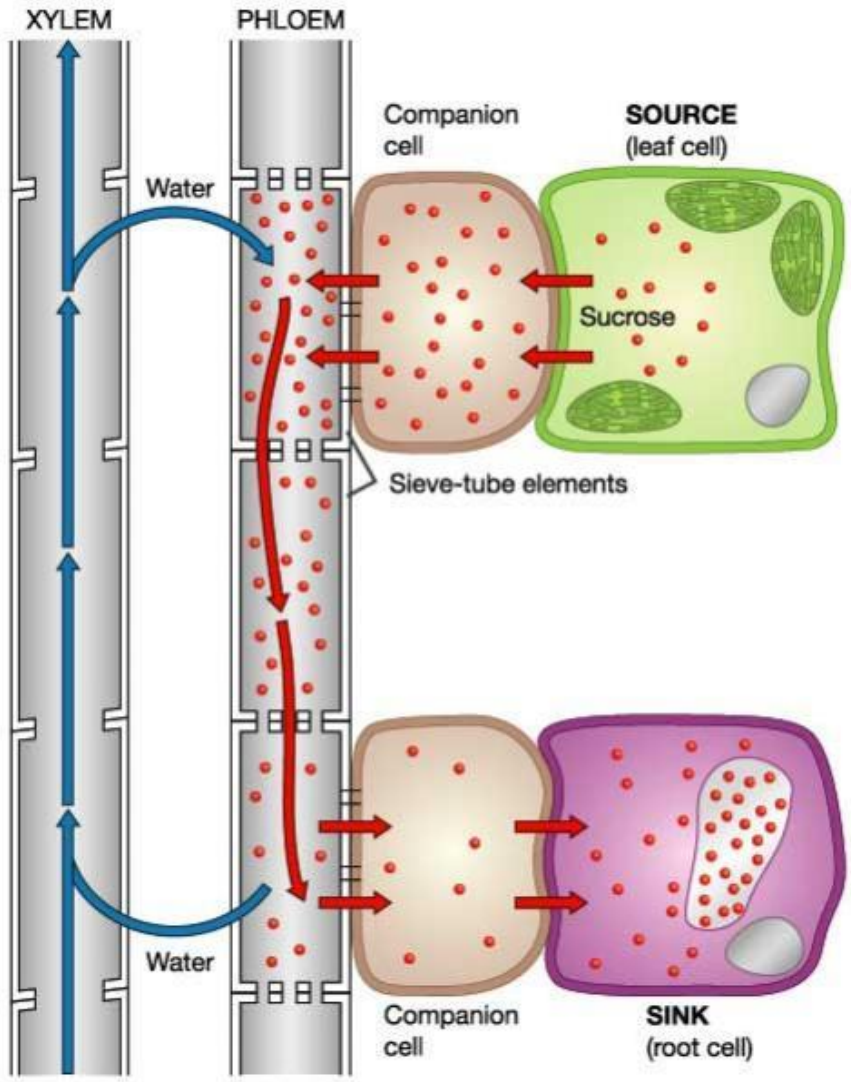


# Translocation in Sieve Tubes

- Water in sieve tubes near sink has **higher hydrostatic pressure** than xylem vessels

→ **Water move back** to xylem vessels

→ Down the hydrostatic pressure gradient




**Lower h.p.**

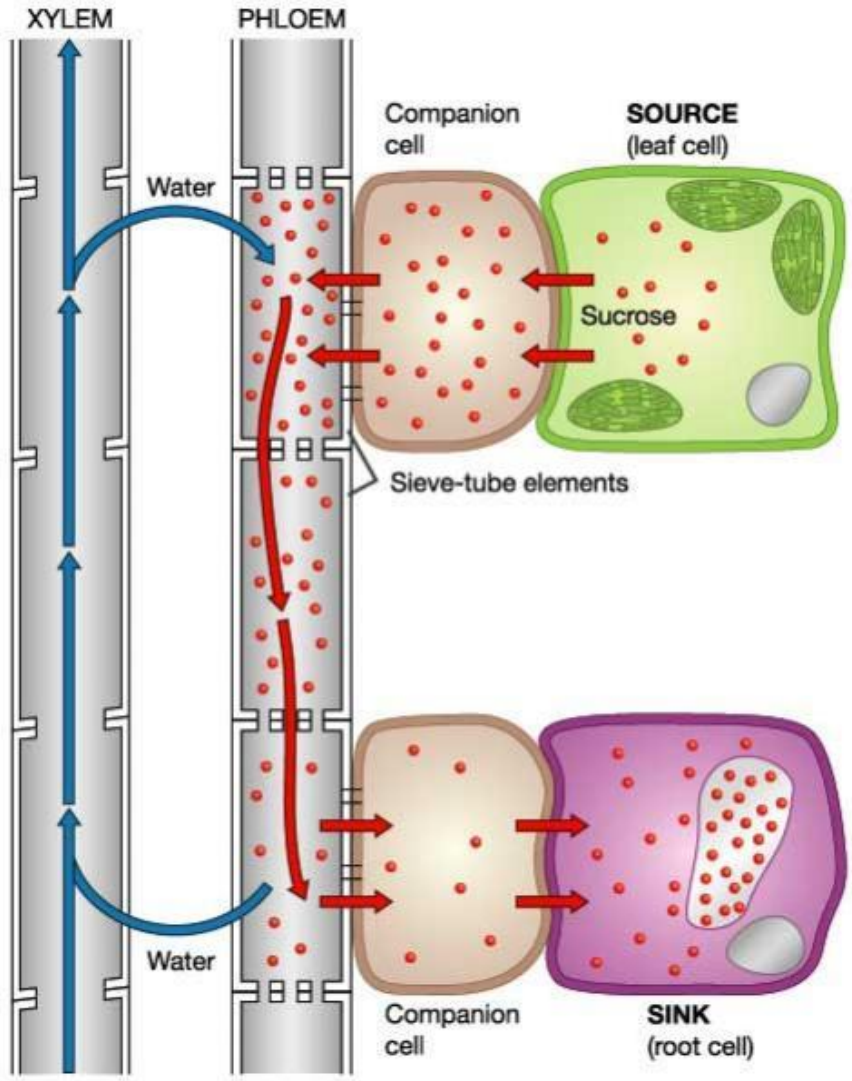
**Higher h.p.**

# Unloading of Sucrose from Sieve Tubes

- Sink has lower concentration of sucrose than sieve tube

→ Sucrose move down its concentration gradient

→ Transported to sink via **diffusion**



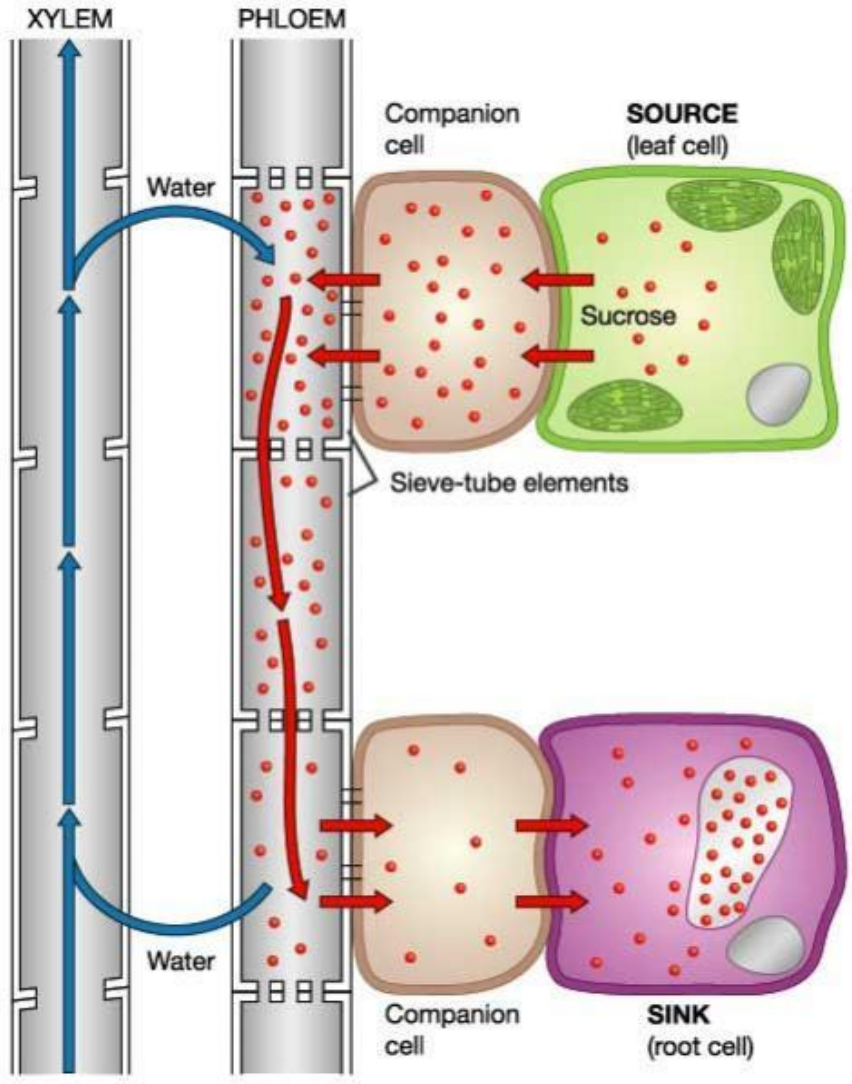
# Unloading of Sucrose from Sieve Tubes

**At sink:**

- Sucrose converted into glucose, fructose, starch

→ Catalysed by Enzymes

→ Use for respiration, growth or storage



# Chapter Outline

**Part 1: Plant Anatomy**

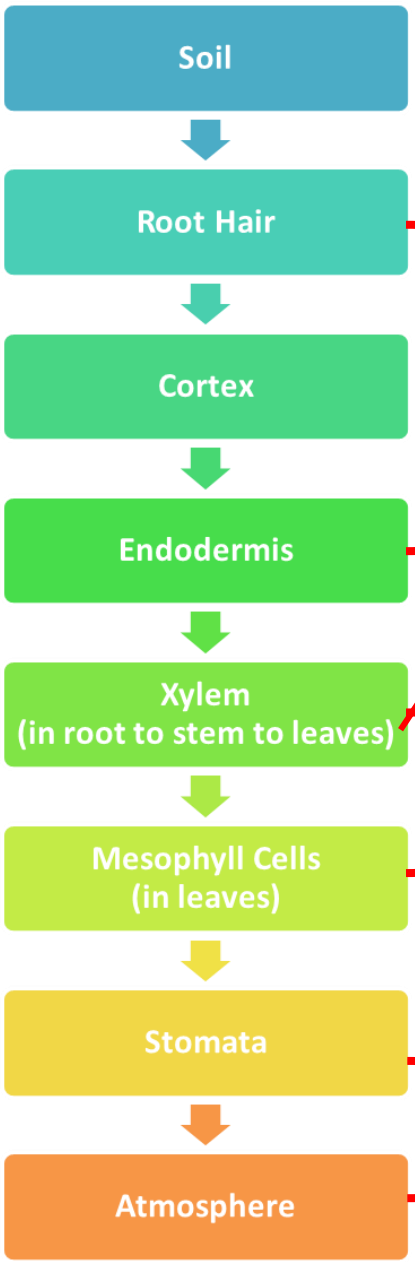
- Structure of Xylem Vessel Elements, Phloem Sieve Tubes and Companion Cells

**Part 2: Transport of Water and Ions**

**Part 3: Translocation of Sucrose**

# Transport of Water and Ions

*always explain in terms of **water potential**




1) Symplastic pathway
2) Apoplastic pathway
   - Casparian strip

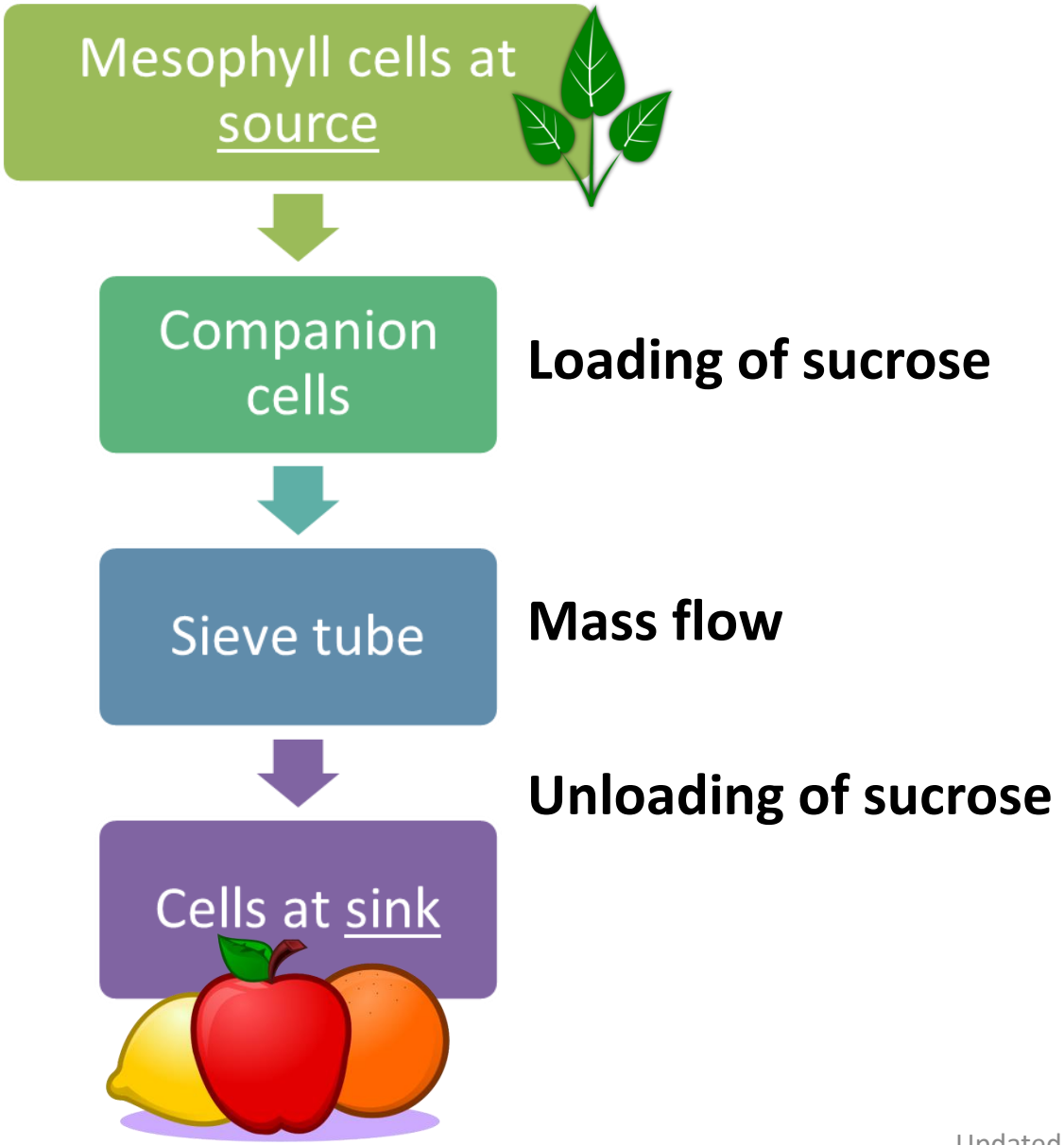
Mechanisms for movement of water in xylem vessels
1) Transpirational pull
2) Cohesion and adhesion of water
3) Root pressure

Symplastic/apoplastic pathway to mesophyll cell surface

Transpiration
- Factors that affect transpiration rate
- Measuring rate of transpiration using a potometer
- Xerophytes: adaptations to reduce transpiration

Updated on 12/8/21 by Beh SJ @behlogy

# Translocation of Sucrose



# Videos

Vascular Plants = Winning! - Crash Course Biology #37
(May help with plant anatomy)
https://www.youtube.com/watch?v=h9oDTMXM7M8

Transportation in Plants (Animated, too simple, but gives a good overview)
https://www.youtube.com/watch?v=JFb-CWlz7kE

Measurement of Transpiration Rates using a Potometer
https://www.youtube.com/watch?v=gXocZZDDPaw

The Pressure Flow Model (aka Translocation, Animated)
https://www.youtube.com/watch?v=3OEd8WDxg1U